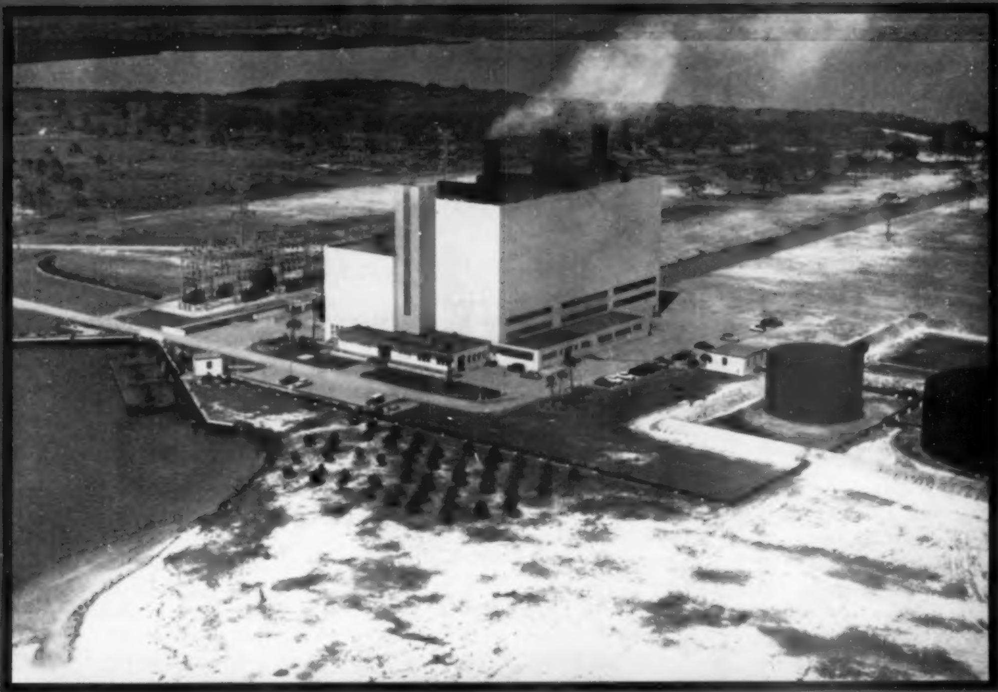
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM-PLANT DESIGN AND OPERATION

April 1957



A. W. Higgins Plant, Florida Power Corp., at Oldsmar, Fla., a few miles from St. Petersburg

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 28 **No. 10**

April 1957

Feature Articles

Editorials

Departments

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BPA

Printed in U. S. A.

rugged blow-down service

YARWAY UNIT TANDEM BLOW-OFF VALVES

When boiler pressures are high you may not "blow-down" very often, but, man, when you do, you're glad those blow-off valves are rugged YARWAY Unit Tandems!

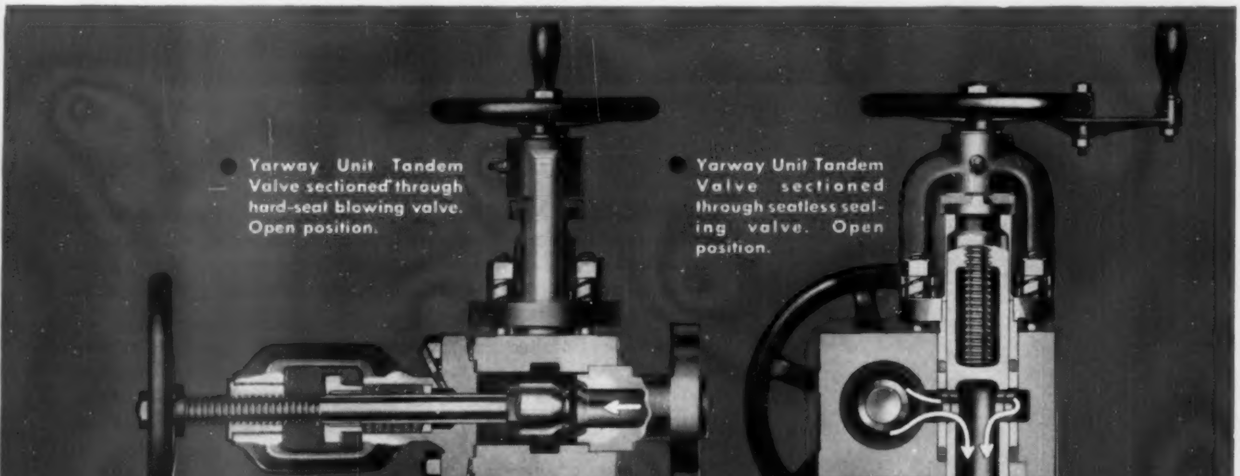
More than 80% of high pressure boiler plants are equipped with YARWAY *Blow-Off Valves,* and there's ample reason.

YARWAYS are strong, heavy-duty valves giving the important extra dependability needed for the severe combination of high pressures (hence high velocities), acid cleaning, and abrasion caused by precipitated solids.

YARWAY Blow-Off Valves also are relied upon to keep boiler level within desirable limits during quick starts of high pressure boilers.

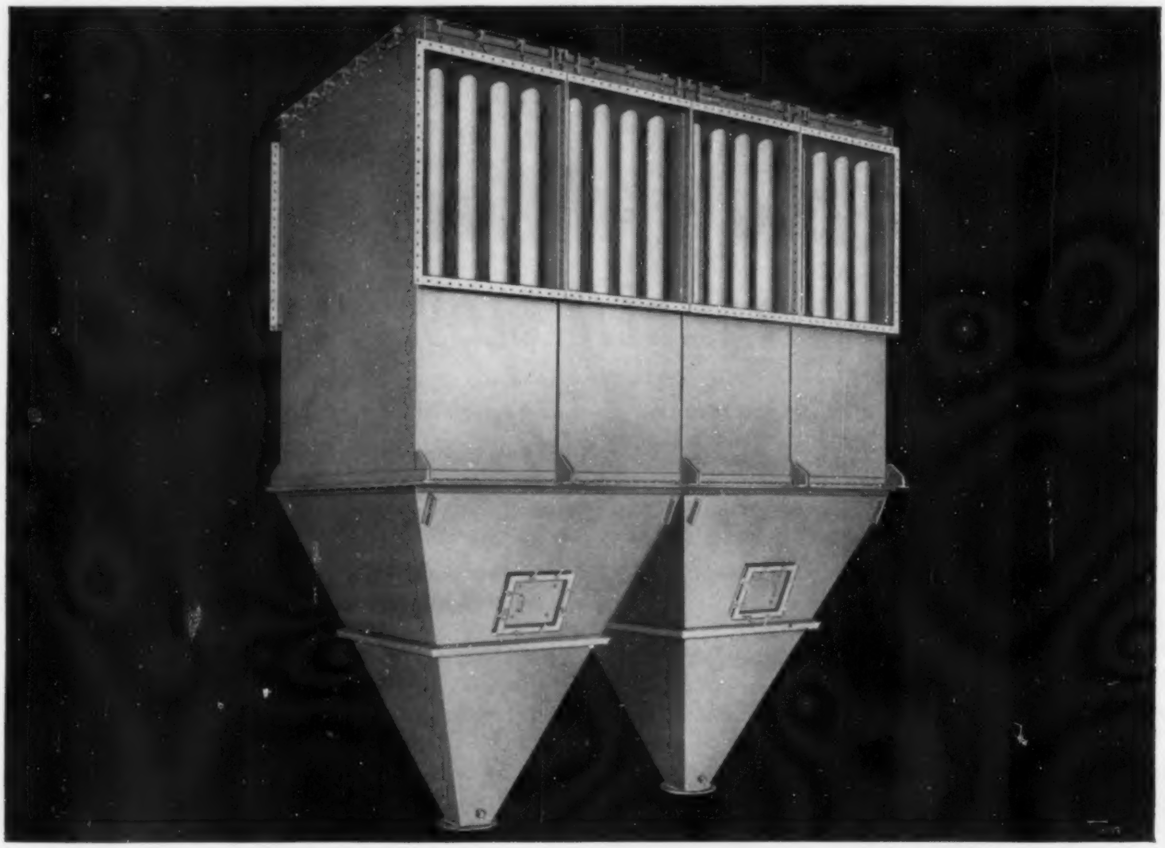
Specify YARWAYS—to protect *your* boilers. Write for Bulletin B-434.

YARNALL-WARING COMPANY
100 Mermaid Ave., Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

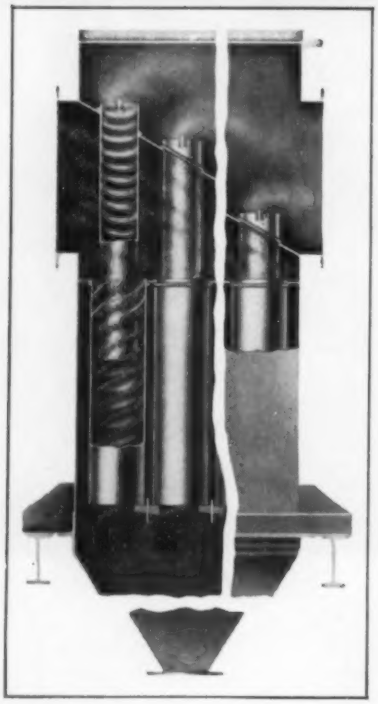


— blow-off valves

Control fly ash with job-fitted



Series 342 Precipitator



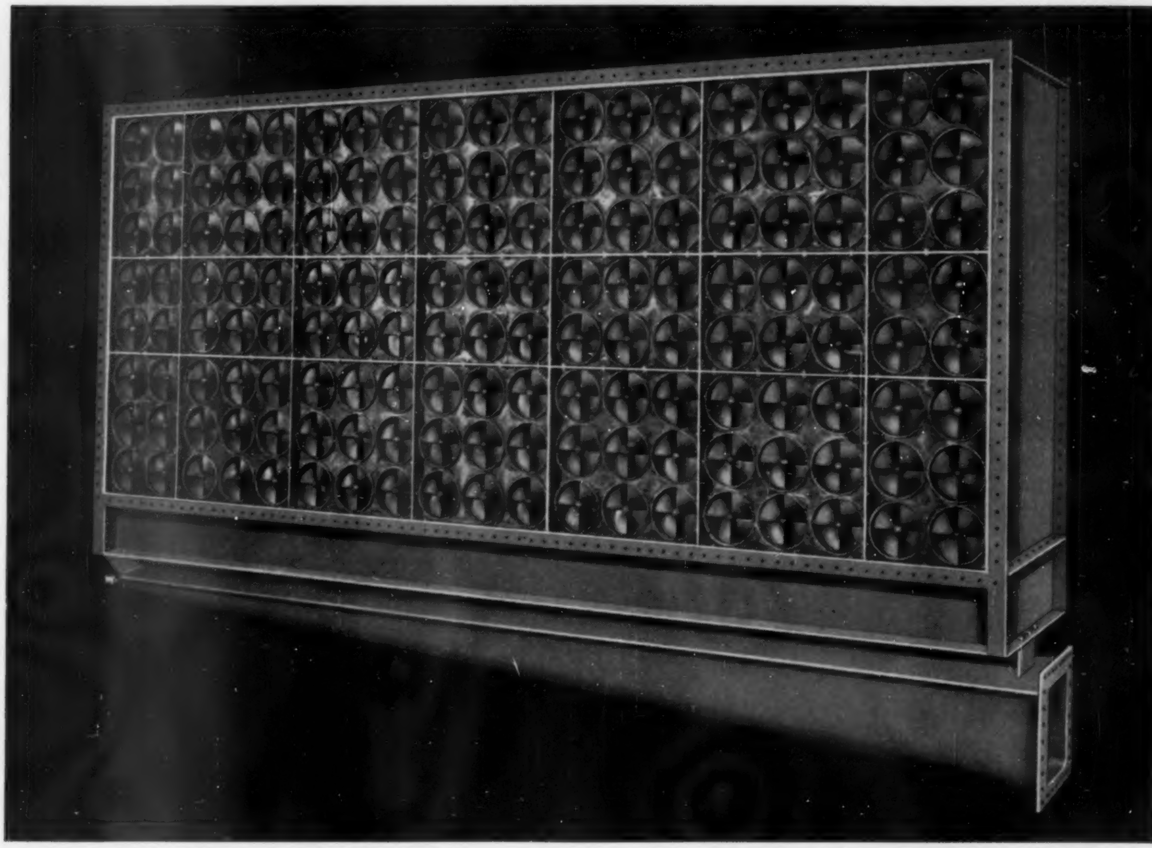
COMPACT DUST COLLECTOR – Series 342 Precipitator meets industry's need for a simple, compact, economical, all-purpose, mechanical-type dust collector. With the growing value of fly ash as a salable by-product, adequate, efficient collection is becoming increasingly important.

Easy to install because of its sectionalized construction, the Series 342 Precipitator has proved effective in controlling dust discharge to the atmosphere in a large percentage of industrial plants. The reason: since each tube assembly is basically an individual cyclone or centrifugal dust collector, the multi-tube Series 342 will deliver an over-all performance comparable to the high efficiency obtained by a single, small-diameter cyclone.

Furthermore, American Blower Series 342 Precipitator features welded-steel construction and removable tubes, is available in a variety of sizes to meet specific job requirements on either new or existing installations.

Dust-laden air or gas enters inlet plenum; gravity and centrifugal action force dust downward, adjacent to tube wall; dust is skimmed into gas-tight receptacle; cleaned air or gas moves upward through outlet tubes to outlet plenum.

American Blower precipitators

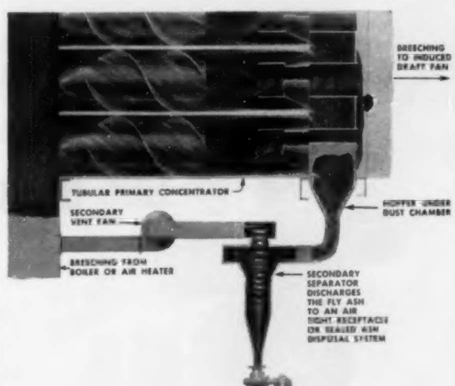


Series 361 Fly Ash Precipitator

FOR LARGE PUBLIC UTILITIES – Series 361 Fly Ash Precipitator offers maximum collection efficiency over entire operating range, occupies minimum space, and gives reliable performance, trouble-free operation.

What's more, the secondary separating system of the Series 361 makes it relatively more efficient at reduced loads when fly ash is finer and more difficult to remove. Then, too, ability to vary number and arrangement of individual cells makes it easy to tailor unit to the particular job.

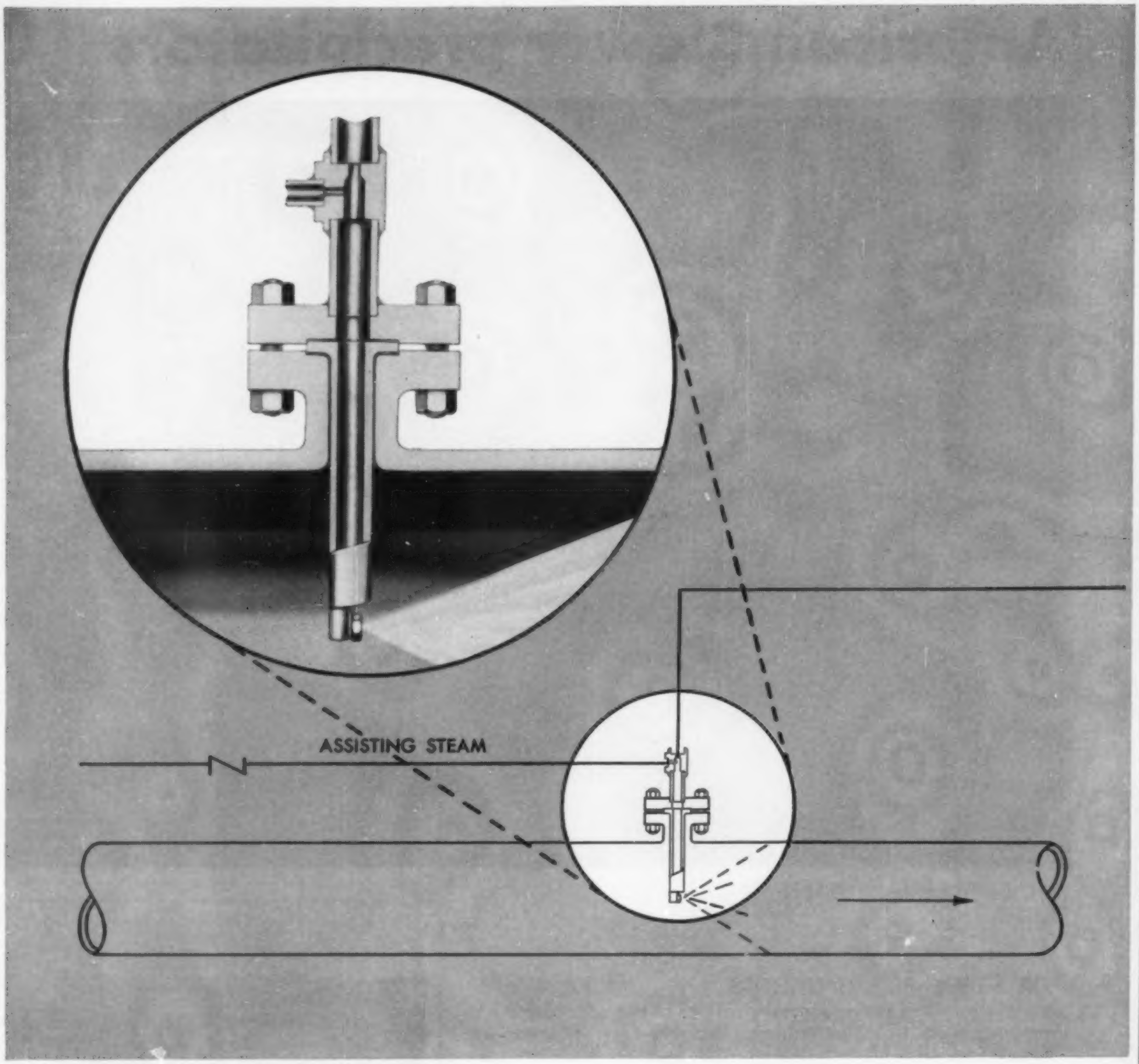
Whatever your dust-collection problem, it will pay you to talk to an American Blower engineer. His knowledge of the application of precipitators and dust collectors can prove invaluable to you. Call your nearest branch, or write: American Blower Corporation, Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ontario.



Secondary system results in velocity-efficiency characteristics which automatically maintain maximum efficiency over entire boiler load or operating range. Properly installed and operated, unit's collection efficiency is from 85% to 90%.

AMERICAN BLOWER

Division of AMERICAN-Standard



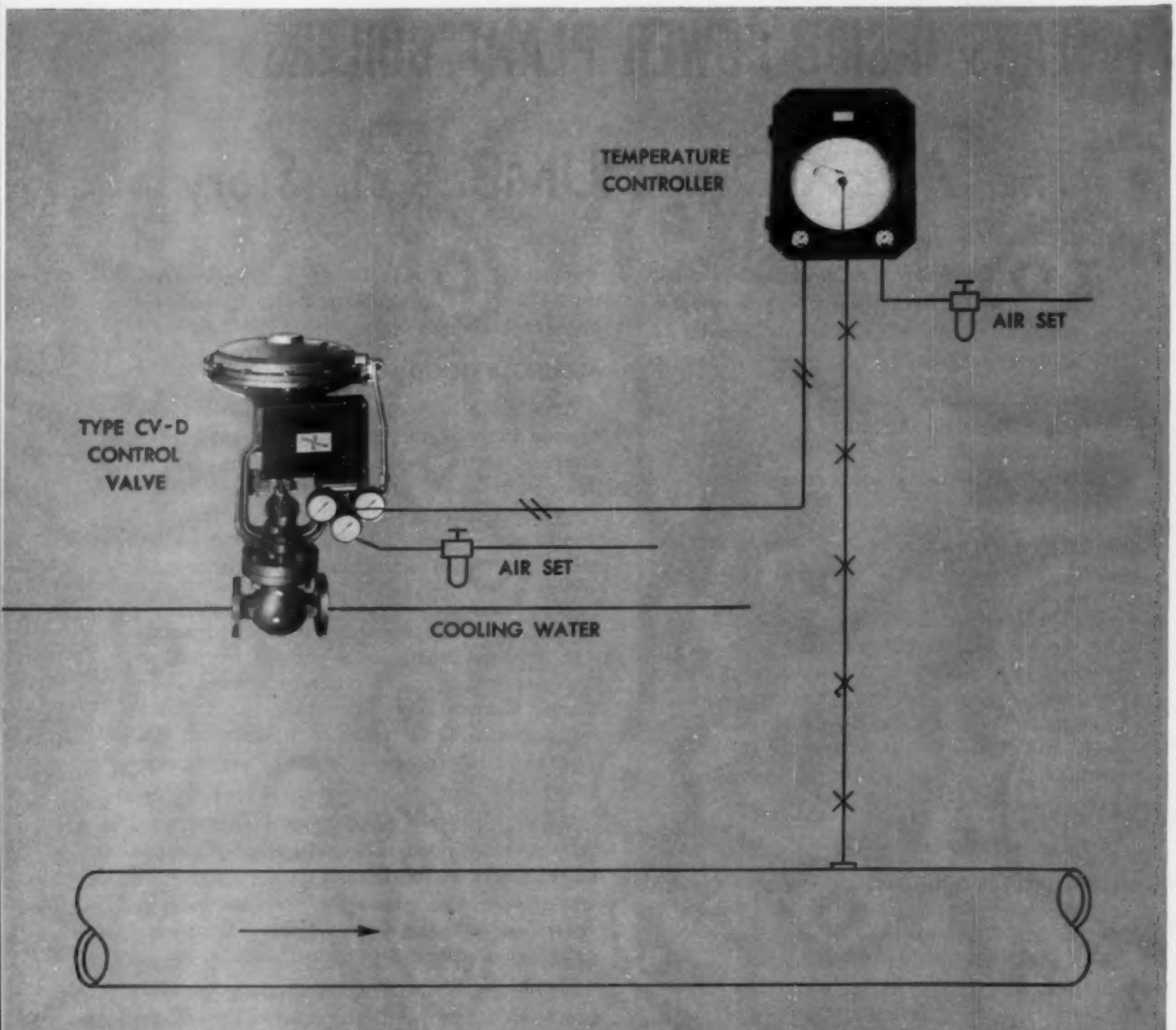
Both carburetor and in-line types are available in the new Copes-Vulcan Steam-Assist Desuperheater.

Get more accurate control with the NEW

Here is a desuperheater based on a new, proven principle that delivers more accurate control of final steam temperature for process work or auxiliaries. It uses steam only on lighter loads. As load increases, the flow of assisting steam is automatically reduced—normally without an atomizing-steam valve. Assisting steam can be off completely at high loads where no more than mechanical atomization is needed. Control is close, even at 10 degrees above saturated temperature.

Cooling water and assisting steam are intimately mixed in the exclusive Swirl Chamber—upstream from the point of injection. No large steam bubbles form to cause annoying hammer or vibration.

Incorporated into the station for close modulating control of cooling water flow is the new Copes-Vulcan Type CV-D



Normal installation of a Copes-Vulcan Steam-Assist Desuperheater is shown schematically

Copes-Vulcan Steam-Assist Desuperheating Station!

Valve. It is designed for the exact operating characteristics suited to your needs.

Enjoy the benefits of Copes-Vulcan desuperheating, custom-engineered for your individual requirements. Be sure of accurate control, minimum maintenance and long service life. Write for Bulletin 1024.

BLAW-KNOX

COPES-VULCAN DIVISION

BLAW-KNOX COMPANY

ERIE 4, PENNSYLVANIA

COPES VULCAN

51 YEARS INSIDE POWER PLANT BOILERS:

The APEXIOR® NUMBER 1® *Story*

"*IF paint can protect structural steel, is it not possible to develop a coating to perform the same function under conditions peculiar to the inside of a boiler?*"

With this question, posed at the beginning of the century by a chemist with an inquiring mind, came a turning point in attempts to step up power production by reducing boiler outage and maintenance costs.

Actually the idea of sealing metal from corrosive influences by means of a protective film was by no means new. Even before the Christian era, warriors of ancient Gaul devised a coating for the first iron weapons—and in 75 A. D. the Roman, Pliny, wrote: "If you desire to protect iron from rust, give it a varnish of ceruse, plaster and tar." Yet many hundreds of years later, well after the start of the Industrial Revolution, little was understood about the mechanism of corrosion and its prevention.

A NEW APPROACH

To this climate, researcher J. Dampney brought a new approach to metal protection. What is to be protected, and why—he reasoned—should determine the how of coating formulation. To put his pioneering end-use theory to the test, chemist Dampney selected an area of service seemingly beyond the scope of brush-applied protection—the inside of a steam-generating pressure vessel. His aim: To devise an inert barrier, simple to apply, capable of isolating steel from all of the complex chemical and physical processes—the variables and unknowns—to which it was exposed.

That thinking, revolutionary for its time, gave birth to the material that first proved itself in service on the inside of a Scotch marine boiler, and in duty ever since in tubes and drums of every kind of vessel built to generate steam. Apexior Number 1, Dampney named it—"higher than the highest"—in justifiable pride for having produced the seemingly impossible.

MAKING A GOOD BOILER BETTER

Here was a brushed-on material that actually became one with the boiler, capable not only of meeting internal operating conditions, but of doing so far more effectively than steel itself—for while Apexior-coated metal remained secure, it also stayed clean. J. Dampney had accomplished more than he had hoped. He had found a way to make even a good boiler better.

The years since 1906, when Apexior Number 1 was first marketed, have brought tremendous advances in power generation—improved boiler design, increased pressures and temperatures, instrumentation, feedwater treatment, and now the era of supercritical pressures and nuclear power.

With all of this progress, Apexior has kept easy pace, serving in boilers of every type, of all sizes and pressures, located in central station, industrial and marine power plants the world around—for the end use for which Apexior Number 1 was originally formulated remains basically unchanged.

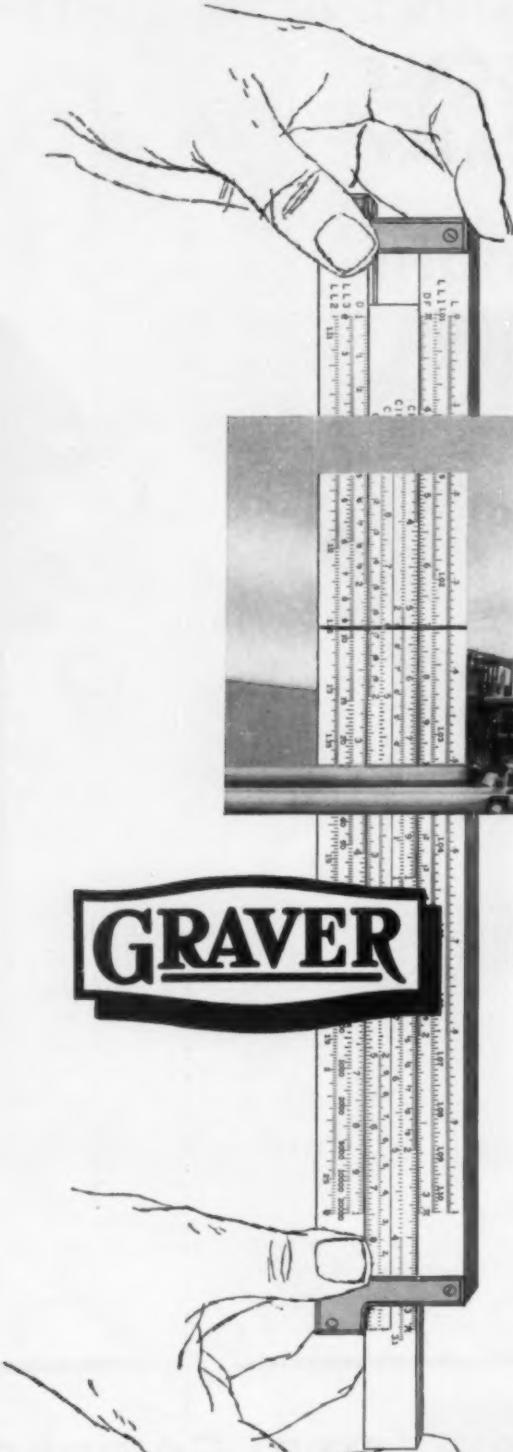
In the words of an expert speaking on water problems at supercritical pressures before the 1955 A. S. M. E. Mechanical Engineering Conference, " . . . . we must still be concerned with deposits that impede heat transfer or lower turbine capacity. We must still guard against the insatiable thermodynamic urge of water to convert iron into iron oxide."

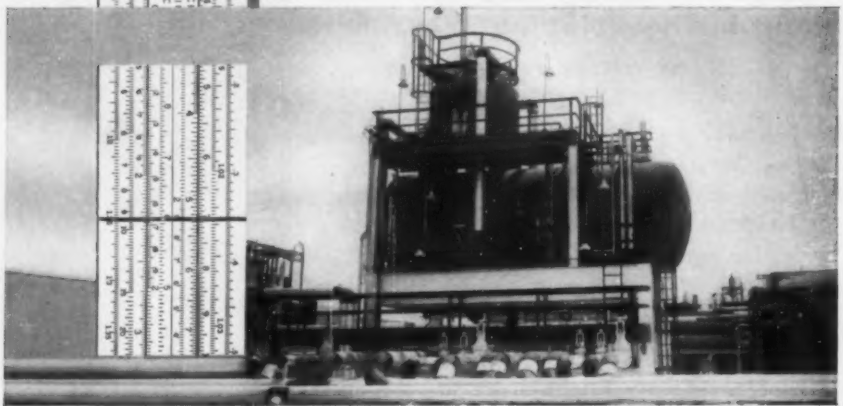
How fifty-one years have strengthened a basically right concept—the story of Apexior Number 1's contribution to modern power generation—will be the subject of future advertisements in this series.

MAINTENANCE FOR METAL

THE DAMPNEY COMPANY

HYDE PARK, BOSTON 36, MASSACHUSETTS





Red hot from heating furnace to a Mitchell bending table, this section of 30" pipe was destined to a Russian vapor line under the First Five Year Plan.

Yes, bending 30" pipe is "old stuff" to the Mitchell organization. Pioneers in the field of prefabricating and installing high-temperature and high-pressure piping, and always abreast of every technical advance, we offer you our 58 years' specialized experience as your unqualified assurance of safety, economy and satisfaction on your next job. Ask us in.

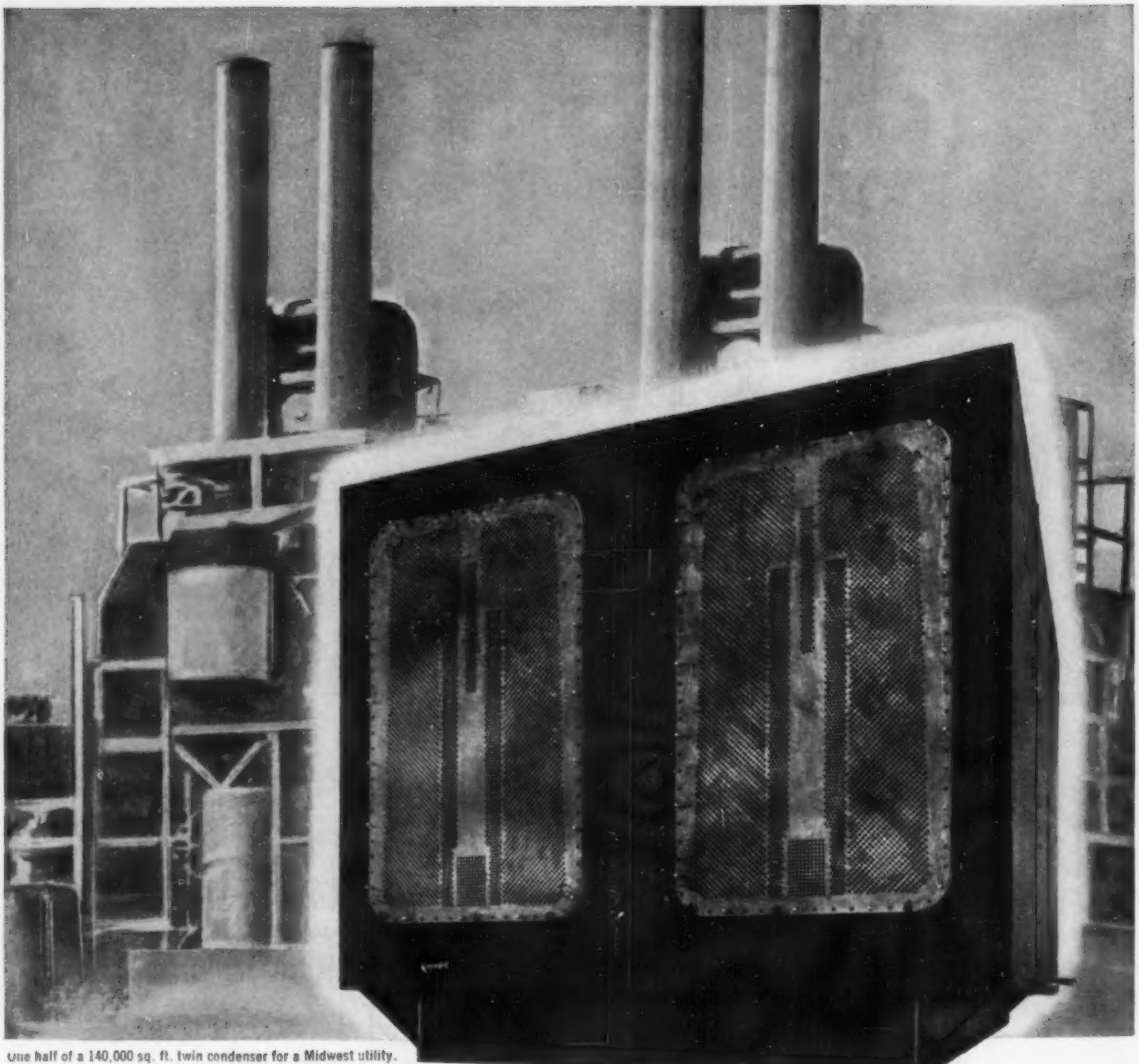
W. K. MITCHELL & CO., INC.

Philadelphia 46, Pa.

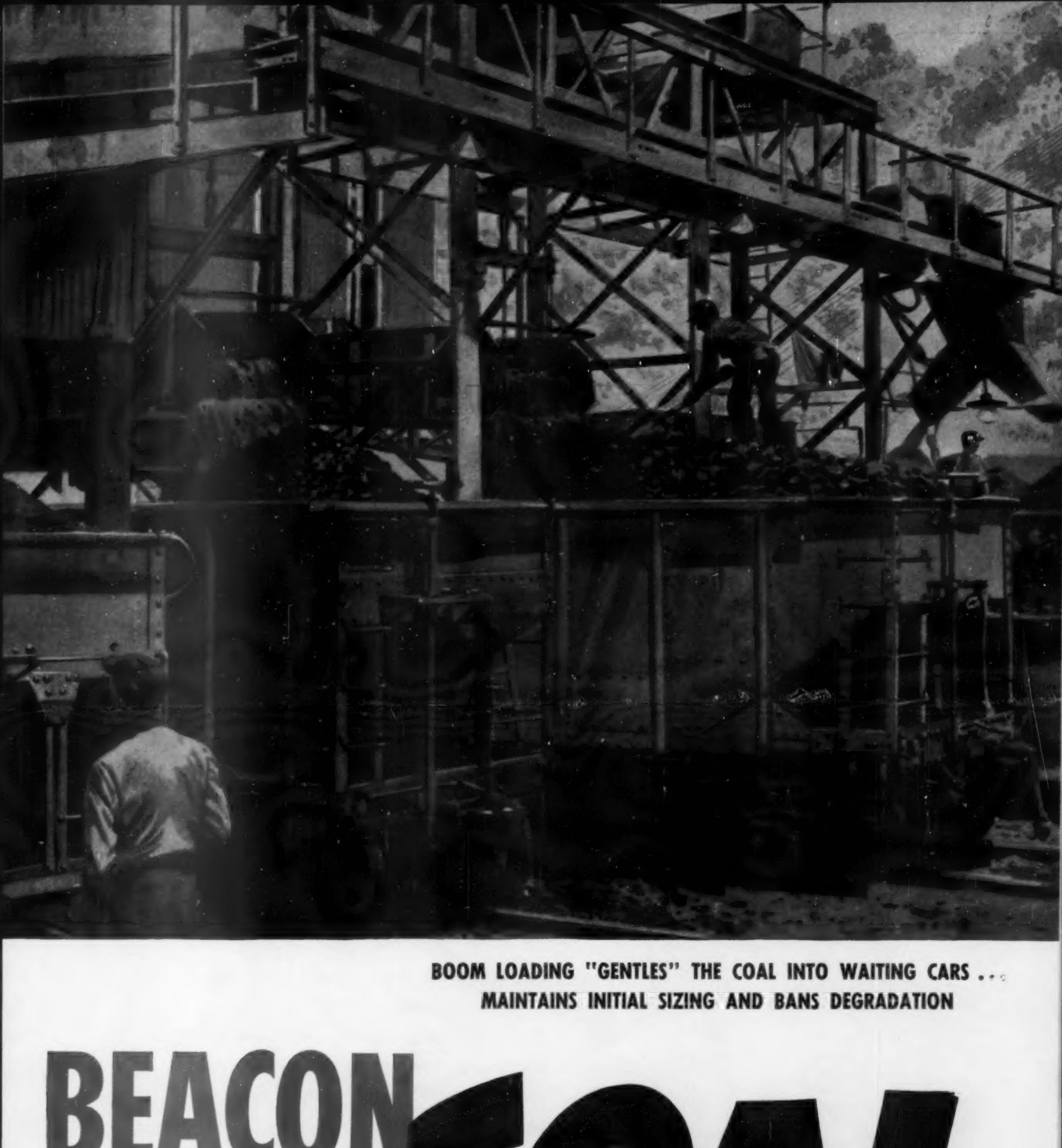
WESTPORT JOINT
(PATENTED)

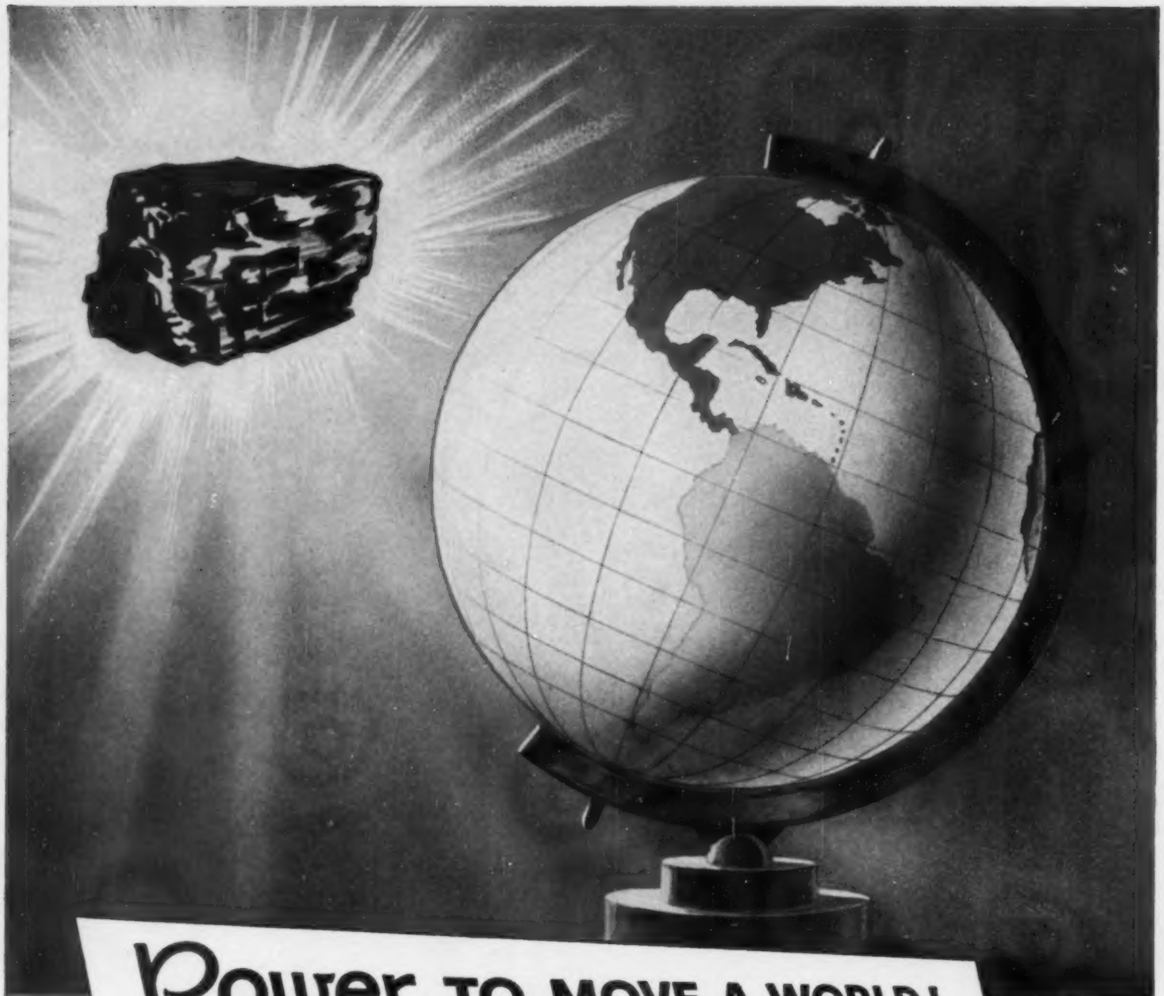
MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS



Une half of a 140,000 sq. ft. twin condenser for a Midwest utility.





Power TO MOVE A WORLD!

➔ America stands on the threshold of a golden age. The sinews of her dynamic economy are flexed as never before. Increased power for untold requirements will be needed . . . and *met* by the most dependable supply of low-cost energy—*Bituminous coal!*

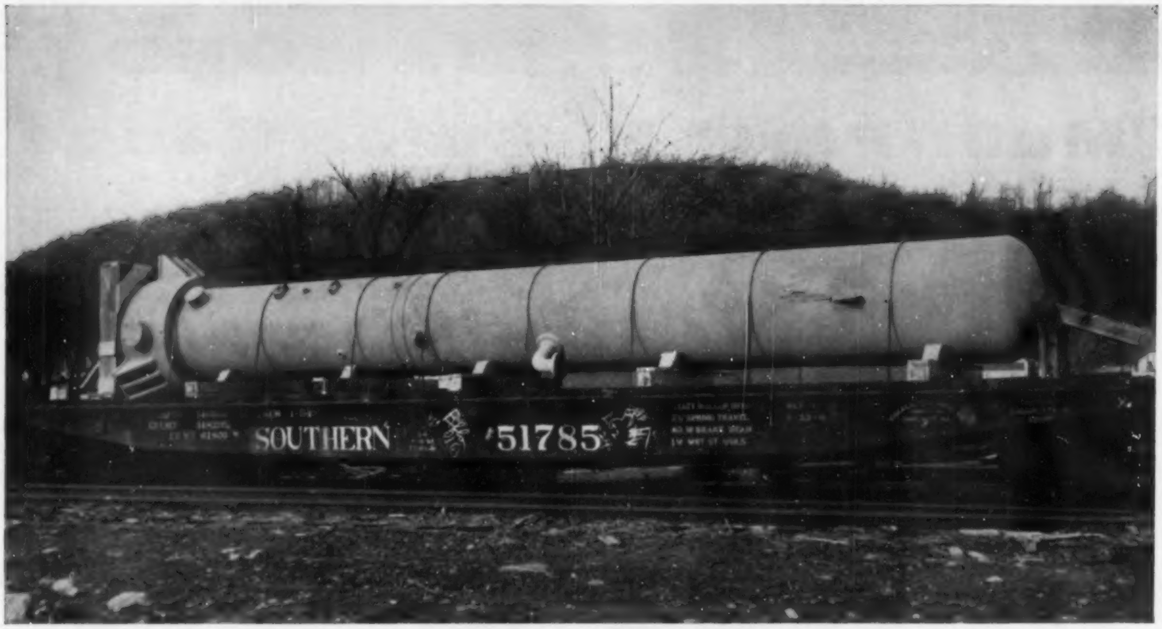
Proven usable reserves in B&O territory contain billions of tons—*available for centuries to come.*

CONTACT OUR COAL TRAFFIC REPRESENTATIVES!
You'll receive details on the most efficient, low-cost Bituminous coal for your particular requirements—
COAL TRAFFIC DEPARTMENT
B&O RAILROAD, BALTIMORE 1, MD. LExington 9-0400

Baltimore & Ohio Railroad

BITUMINOUS COALS FOR EVERY PURPOSE

B&O



All-welded feedwater heater for new generating station will operate at 3200 psi with inlet steam temperature of 678° F. Designed and fabricated by The Lummus Company, the unit is the first of its kind, is also the biggest heater ever built for operation at pressures above 3000 psi, having 12,710 square feet of tube surface in a single shell.

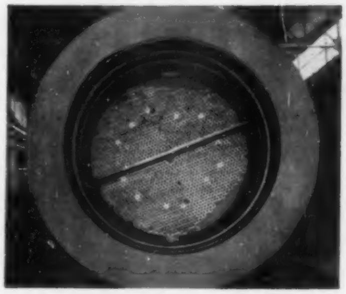
First All-Welded Feedwater Heaters Will Cut Generating Station Maintenance Costs

The first all-welded feedwater heaters ever built have been designed and fabricated by Lummus for the Linden Generating Station of the Public Service Electric and Gas Company of New Jersey. When completed, the installation will include 6 all-welded heaters, designed to operate at pressures well above 3000 psi, and 12 low pressure heaters which were all welded except for the tube to tube sheet joints.

In addition, Public Service has just given Lummus a contract to supply feedwater heater requirements for their new Bergen Generating Station, duplicating in design the Linden units.

Welded construction minimizes leaks in tubes, shell and head. Thus the new units are expected to reduce materially the costly maintenance and downtime associated with failure of seals in bolted and gasketed constructions.

These unique heaters are the end result of over ten years of design and experimental work by The Lummus Company with all-welded fabrication. Perhaps this pioneering can help you reduce maintenance problems, too. For more information write The Lummus Company, 385 Madison Avenue, New York 17, New York.



Ends of cupro-nickel tubes are jointed to steel tube sheet by Inco "140" Monel Ni-Cu alloy electrodes. This alloy fuses well with both tube and sheet materials, forms strong, sound joint.

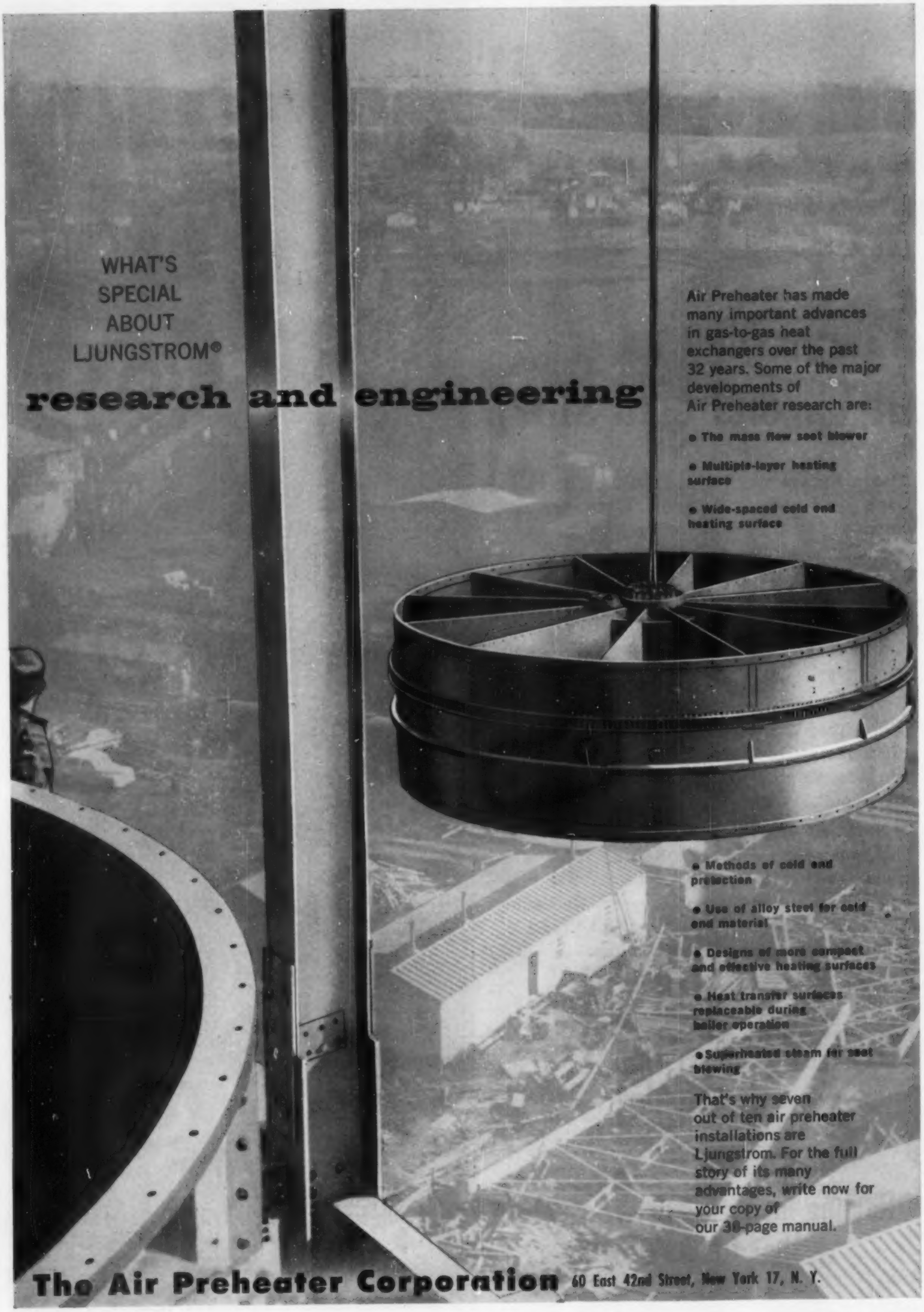
Closed head shows torus ring seal which is welded to channel and cover. Gasketed joint has been eliminated to avoid possibility of leakage. Design water pressure of unit is 3600 psi.

LUMMUS

HEAT EXCHANGER DIVISION

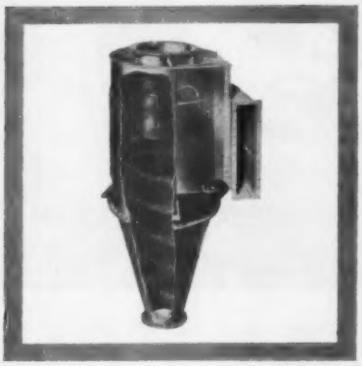
THE LUMMUS COMPANY, Heat Exchanger Division, 385 Madison Avenue, New York 17, N. Y. Atlanta • Boston • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • East Chicago (Indiana) • Houston • Kalamazoo • Kansas City • Los Angeles • Memphis • Minneapolis Nashville • New Orleans • Newton (Iowa) • Niskayuna (New York) • Omaha • Pittsburgh Salt Lake City • San Francisco • Springfield (Mass.) • Syracuse • Toledo • Wayne (Pa.) • Athens Buenos Aires • Caracas • The Hague • Lima • London • Mexico City • Montreal • Paris Rome • San Juan

Steam Surface Condensers • Evaporators • Extraction Bleeder Heaters • Steam Jet Air Ejectors Steam Jet Refrigeration • Barometric Condensers • Heat Exchangers for Process and Industrial Use • Process Condensers • Pipe Line Coolers

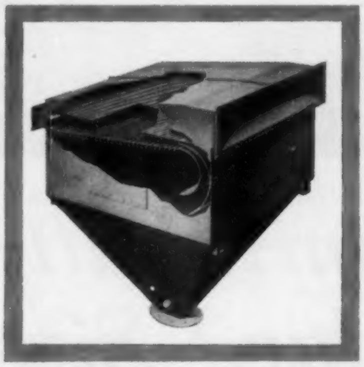

WHAT'S SPECIAL ABOUT LJUNGSTROM®
research and engineering
Air Preheater has made many important advances in gas-to-gas heat exchangers over the past 32 years. Some of the major developments of Air Preheater research are:
• The mass flow soot blower
• Multiple-layer heating surface
• Wide-spaced cold end heating surface
• Methods of cold end protection
• Use of alloy steel for cold end material
• Designs of more compact and effective heating surfaces
• Heat transfer surfaces replaceable during boiler operation
• Superheated steam for soot blowing
That's why seven out of ten air preheater installations are Ljungstrom. For the full story of its many advantages, write now for your copy of our 30-page manual.
The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

How Buell's Exclusive Rapping Mechanism delivers Extra Dust Collection Efficiency

Complementing the extra efficiency of rapping in Buell "SF" Electric Precipitators, the unique Spiralectrodes add further efficiency through 50% to 100% higher electron emission, constantly accurate spacing, longer electrode life.



Buell Cyclones offer two "extra-efficiency" advantages: (1) exclusive Shave-off which harnesses double-eddy and puts it to work, and (2), large diameter design which eliminates clogging.

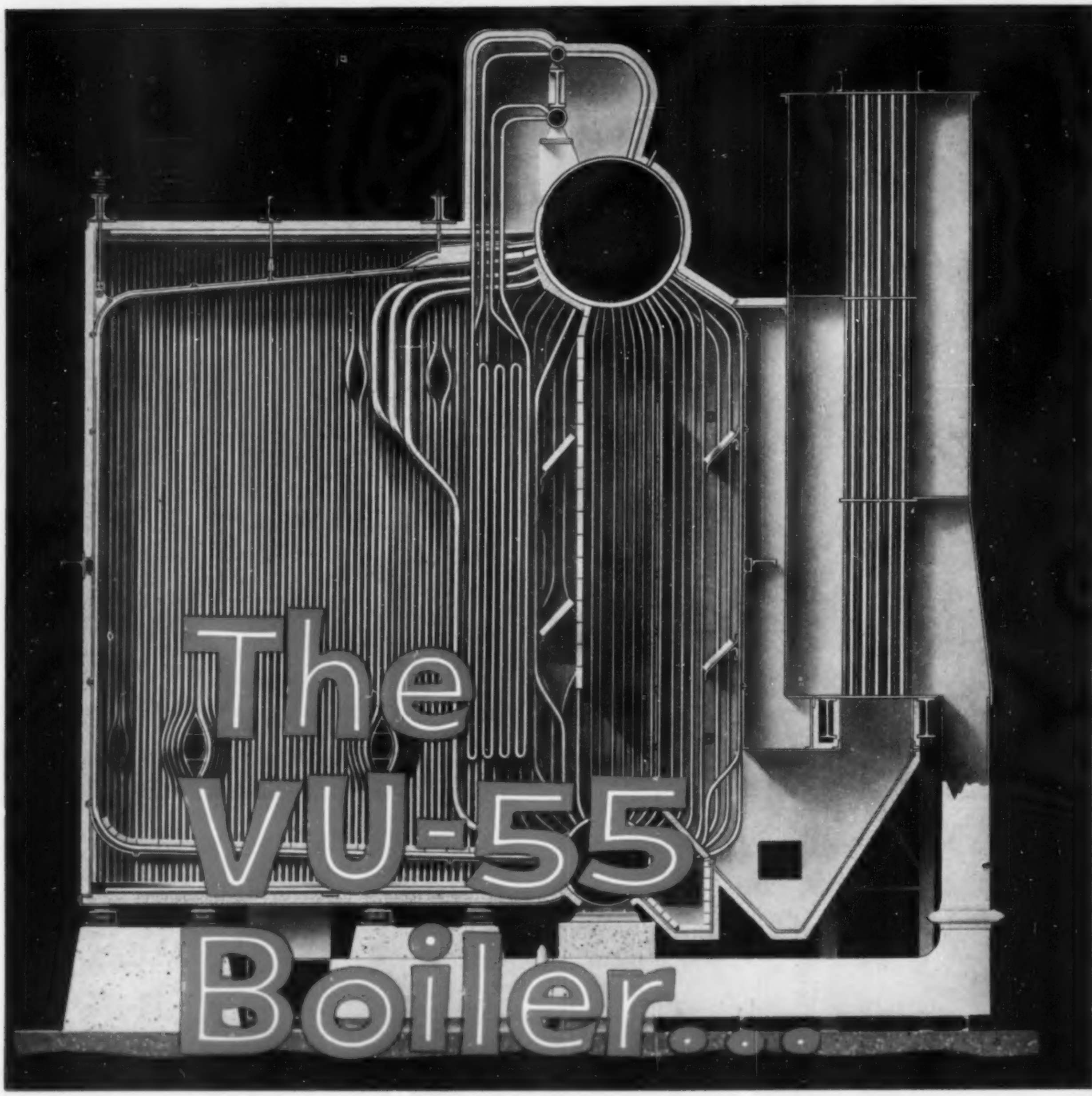


Buell's Low Resistance Fly Ash Collector combines top efficiency with low draft loss, for natural or forced draft installations. Ideal for boilers from 100 to 2000 BHP.

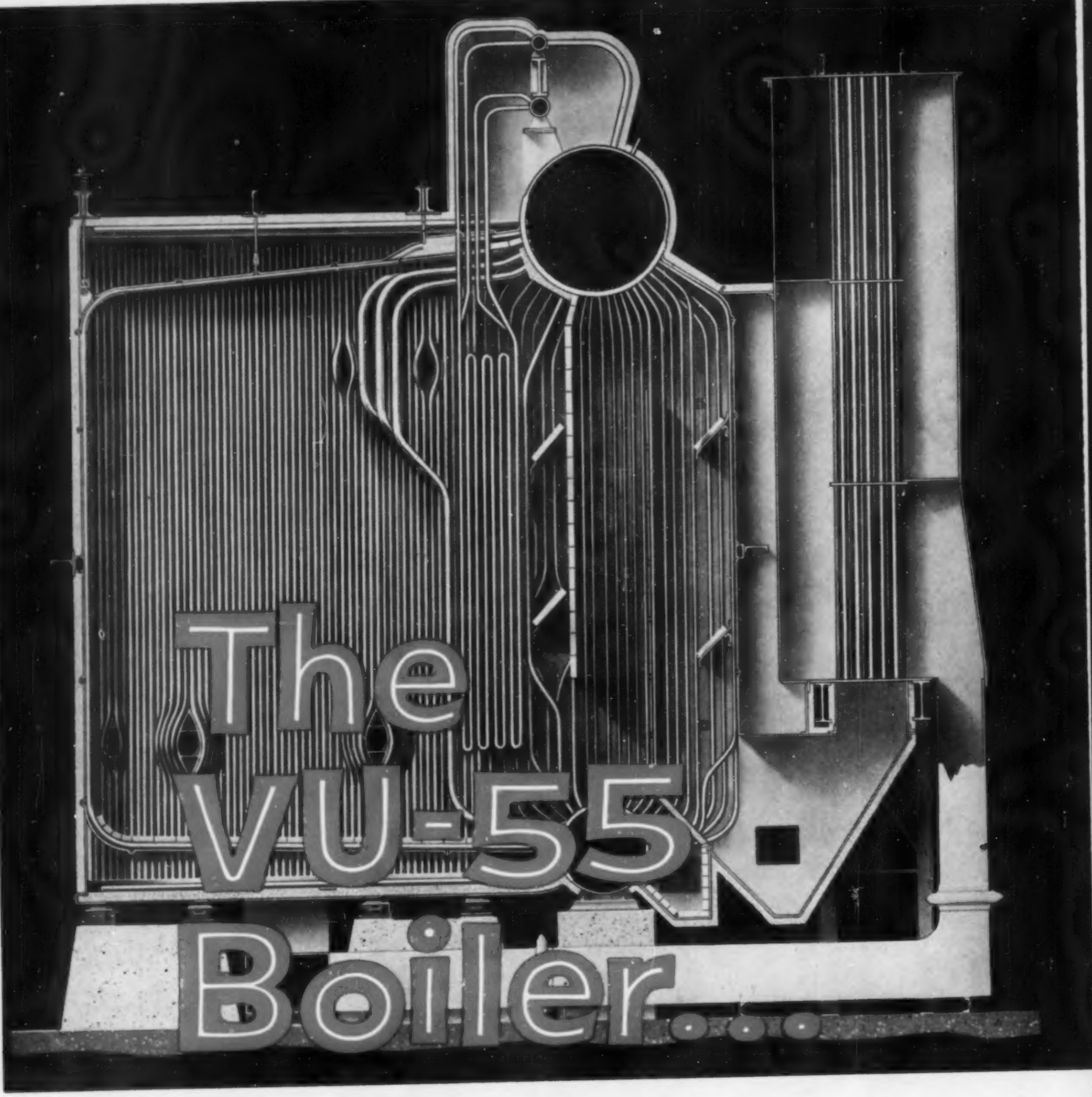
For more specific data about Buell's *extra efficiency*, write Dept. D-70
Buell Engineering Company,
70 Pine Street, New York 5, N. Y.

buell®

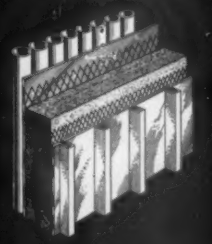
MECHANICAL ELECTRICAL *Experts at delivering Extra Efficiency in* **DUST COLLECTION SYSTEMS**



Custom Features,
Standard Sizes,
Advanced Design



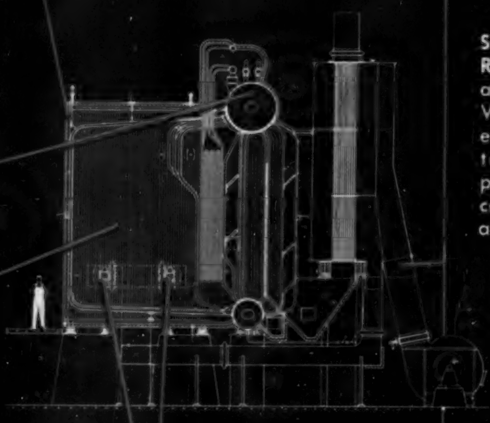
Custom Features, Standard Sizes, Advanced Design



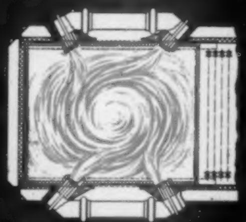
DOUBLE WALL, PRESSURE-TIGHT CASING. The latest development in casing construction for pressure firing of boilers in the size class of the VU-55, this casing is designed to assure life-time tightness with minimum heat loss. Pressure firing permits the elimination of an induced draft fan with its attendant operating and maintenance costs. Construction consists of tangent tubes backed up successively by welded steel panels, 4 inches of high quality insulating material and an outer steel casing formed as shown to provide adequately for expansion and assure ample strength. Low heat loss and the tightness required for pressure firing are assured by this double-wall construction.

HIGH STEAM QUALITY. Equipped with a large (60-in.) steam drum, the VU-55 has generous water capacity and steam reservoir space. C-E drum internals assure high quality steam at all ratings.

TANGENT FURNACE TUBES. The VU-55's furnace tube arrangement provides complete heat-absorbing, water-cooled protection on all furnace walls. Furnace maintenance is minimized, refractory expense is eliminated, heat absorption rates per sq. ft. are higher.



STREAMLINED EXTERIOR. The over-all appearance of the VU-55 reflects the efforts of its designers to achieve a completely unobstructed casing, while retaining adequate access wherever required and every facility for convenient operation. There are no outside downcomer tubes, and the ducts from air heater to burners are beneath the furnace floor.



TANGENTIAL FIRING. More than 20 years of application experience have established the exceptional advantages of tangential firing. About 90 percent of Combustion's large utility installations use this advanced method of firing. Flame streams from the four burners impinge upon one another at high velocity, as shown, creating a turbulence unattainable by any other method of firing. The result is rapid and complete combustion. As the gases spiral upward, they sweep all furnace heating surfaces, assuring a high rate of heat absorption.

The VU-55, newest of the C-E line of Vertical Unit Boilers, represents the closest approach to central station performance yet achieved in standardized boilers in its capacity range.

Its design combines a number of time-tested and service-proved features, such as Tangential Burners, double wall, pressure-tight casing, and tangent furnace tubes. In addition, this bottom-supported unit requires no outside supporting steel, is economical of space and streamlined in appearance.

It is available in 5 sizes for capacities from 50,000 to 120,000 lb per hour. It is designed for 3 pressure ranges (250, 500 and 750 psi) and can be equipped with a superheater to provide temperatures up to 750 F. Either a tubular or a regenerative air heater is available.

The VU-55 Boiler is symmetrical in design, performs efficiently over a wide range of output, and is easy to operate and maintain.

It is, in fact, the boiler with the custom features and the advanced design.

COMBUSTION ENGINEERING

C-E

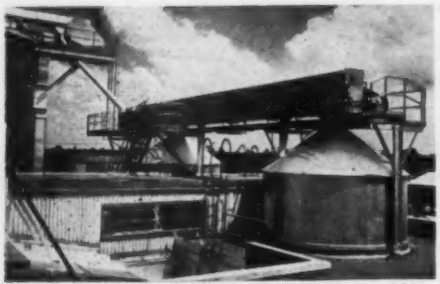
B-978

Combustion Engineering Building

200 Madison Avenue, New York 16, N. Y.

Canada: Combustion Engineering-Superheater Ltd.

all types of steam generating, fuel burning and related equipment; nuclear reactors; paper mill equipment; pulverizers; flash drying systems; pressure vessels; soil pipe.

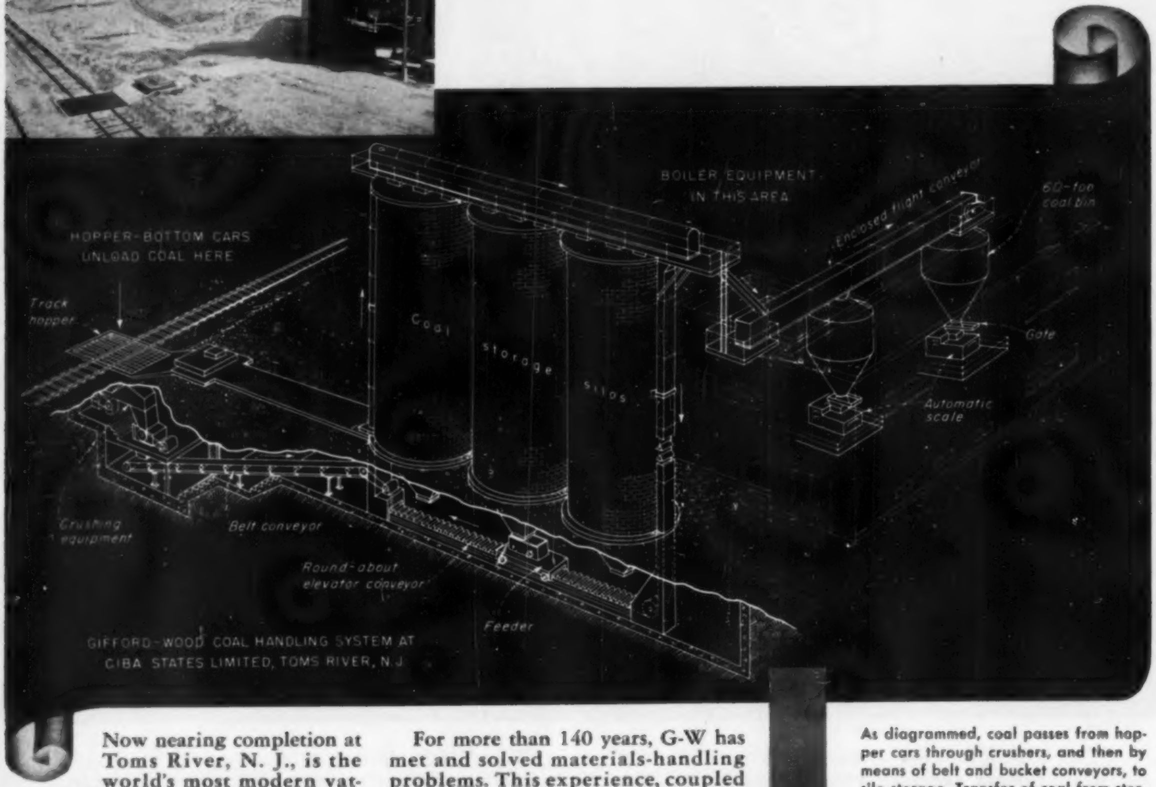


Enclosed flight conveyor and 60-ton coal bin.

Under-track hopper and coal storage silos.

ANOTHER G-W AUTOMATIC COAL HANDLING SYSTEM...

this time for Ciba States Ltd.



Now nearing completion at Toms River, N. J., is the world's most modern vat-color producing plant—and helping insure maximum power development with top economy will be the most efficient coal handling system, by Gifford-Wood. The system was designed and built by G-W engineers for Ciba States Limited, and includes unloading, storage, and feeding facilities.

For more than 140 years, G-W has met and solved materials-handling problems. This experience, coupled with planned application of the most modern equipment, is at your disposal. This project is only one example of complete design, construction, and erection under one responsibility

For details on this, or other Gifford-Wood coal handling installations, please write for Bulletin No. 300.

As diagrammed, coal passes from hopper cars through crushers, and then by means of belt and bucket conveyors, to silo storage. Transfer of coal from storage silos is by gravity feed into a movable car from which the bucket elevator lifts it, by-passing the storage silos, to an enclosed flight conveyor discharging into bins, which feed through coal scales to pulverizers.

GIFFORD-WOOD CO.

Since 1814
Hudson, New York

New York 17	St. Louis 1	Chicago 6
420 Lexington Avenue	Railway Exchange Building	565 West Washington Street

8756

When You Think of Materials Handling—Think of Gifford-Wood

Hall Industrial Water Report

VOLUME 5 APRIL 1957 NUMBER 2

A New Broom Sweeps Water Clean

Coagulant aids are not new, but, just as in the old saying, the newer types of coagulant aids are helping the common coagulants to sweep water freer of suspended matter at lower chemical and operating costs and higher clarifier flow rates. The cleaner water solves problems wherever water is used; in boilers, municipal systems, cooling systems, waste disposal, oil well floods. Hall Laboratories engineers are fully informed on what various aids can do and are ready to help you with your clarification problems.

Flow Rate Doubled With Coagulant Aid

Carryover of floc from large clarifiers in a southern plant was a serious problem because the suspended material adsorbed from the water the glassy phosphate added for control of corrosion in the extensive cooling system.

Water used for cooling purposes was clarified with ferric sulfate and ground calcite. There were no filters, so good clarifier operation was essential. But the floc formed was so fragile and had such poor settling characteristics that the plant operated at one-half capacity part of the time to avoid losing the sludge blanket. During these periods one-half of the cooling water used was not clarified.

Hall Engineers M. C. Scott and V. M. Marcy substituted 6 ppm of a Hagan Coagulant Aid for the calcite. The large, tough floc resulting permitted operation of the clarifiers at full load and with greatly reduced chemical feed.

A water of satisfactory quality is now being produced at a saving of approximately 50 per cent in chemical cost. As a bonus, there are potentially greater savings resulting from the improved water conditions and protection from corrosion.

From Muddy River To Deionized Water

The water used in the electrolytic tinning lines at a Pennsylvania steel mill must be free from suspended material and low in dissolved solids. To make water of such high quality requires complete clarification and deionization.

Until approximately a year ago the first important step of removing suspended matter from the muddy river water was accomplished with aluminum sulfate and lime in clarifiers. The quality of the water going to the deionizers was not all that it should be because the sludge blankets were sensitive to increase in upflow rates and there was trouble with settling of floc.

Hall engineer D. E. Noll recommended the use of a Hagan Coagulant Aid to improve clarifier operation. Results were successful. The sludge blankets stabilized and the floc toughened and settled more rapidly. Time-consuming jar testing previously used for control has been completely eliminated. Feeds of aluminum sulfate and lime were reduced approximately 30 per cent with corresponding reduction in chemical handling and storage space.

An additional saving resulted from reduction in regeneration chemical cost at the deionizing plant. Coagulant aid has surely carved a niche for itself in this plant.

Clarifying Potable Water

A Western Pennsylvania municipal water plant had trouble with floc formation when clarifying with lime and aluminum sulfate. This plant clarifies and filters 15 to 20 mgd of river water in a conventional sedimentation basin. Coagulant aids have eliminated the difficulty. Operating experience showed that both activated silica and a Hagan Coagulant Aid greatly improved floc formation at approximately the same chemical cost. The plant chose Hagan Coagulant Aid because operating cost was reduced by dry-feeding it in comparison with the more time-consuming task of preparing the activated silica sol.

An Aid to Silica Removal

Turbidity in the effluent from the hot-process unit was affecting silica removal at a paper mill in Virginia. Carryover of suspended material became particularly severe on sudden load surges. Often the particles were so finely divided that they passed through the anthracite filters to the paper mill boilers.

The raw makeup water for the 600-psig boilers contains 230 ppm bicarbonate, 30 ppm silica, practically zero hardness, and about 3 ppm of naturally occurring phosphate. Hydrogen cycle exchangers reduce the high alkalinity, while the following treatment with caustic soda and magnesium sulfate and oxide in the hot process unit reduces the silica concentration of the filter effluent to about 2 ppm.

Hall engineer C. F. Raines decided to try a Hagan Coagulant Aid for better settling of suspended matter in the hot-process unit, even though there had been no previous experience with the Hagan aid for such an application.

A few ppm produced amazing results. The effluent from the unit was clear even before filtration and the filter effluent was sparkling clear.

In addition to reducing sludge carry-over, the 8-10 ppm coagulant aid feed resulted in the same degree of silica removal with 15 per cent less magnesium salts.

Both the plant operating staff and engineer Raines are justifiably pleased with the truly outstanding improvement in water conditions.

Industrial Water Problems Require Special Handling

There are no "stock answers" to industrial water problems. For information write, wire or call Hall Laboratories, Division of Hagan Chemicals & Controls, Inc., Hagan Building, Pittsburgh 30, Pa.

Water is your industry's most important raw material. Use it wisely.

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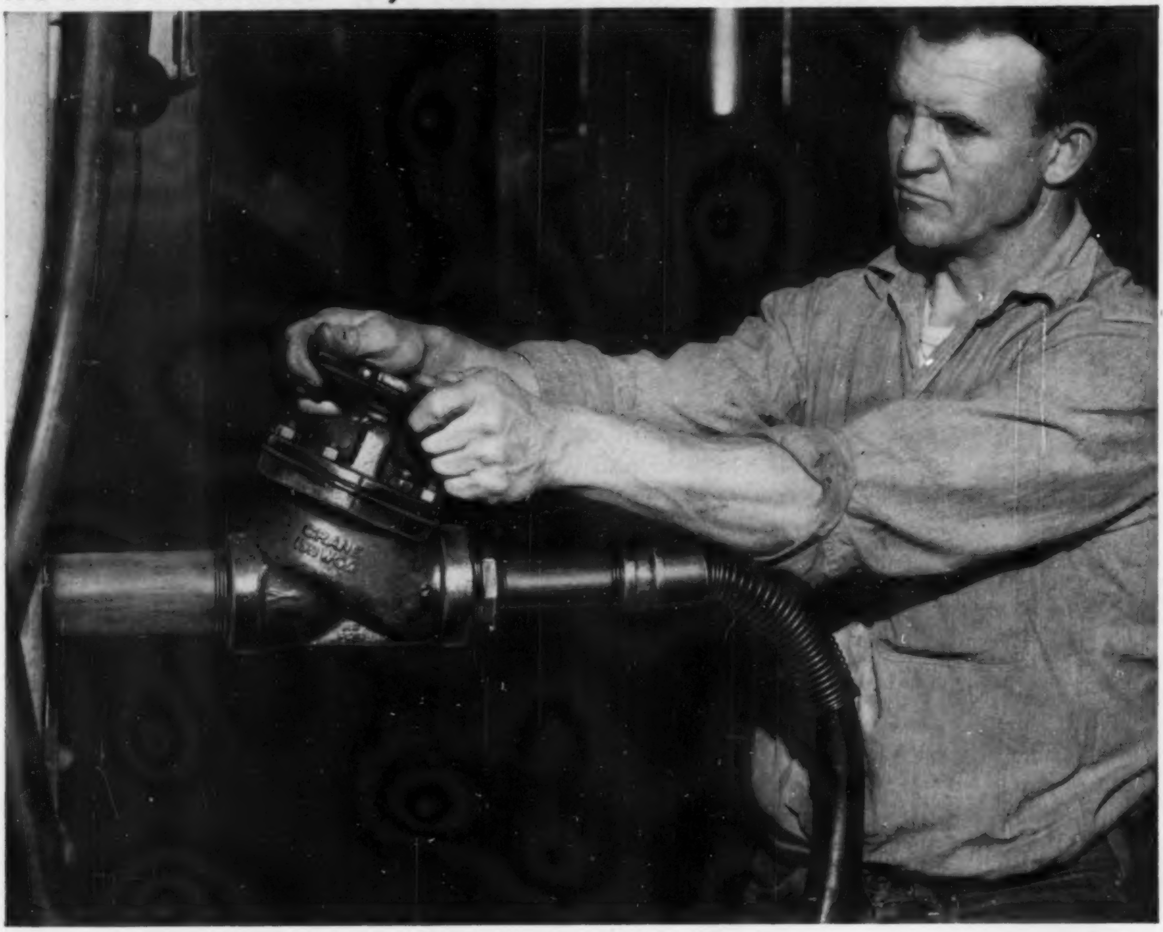

Utility finds these valves ideal for holding transformer oil

Note how clean the valve—not even a sign of oil seepage.

Two years ago, Southern California Edison Co. at its Alhambra shops installed this Crane diaphragm valve on oil refill lines for transformer servicing. Operated about 12 times daily, it has never shown any sign of leakage.

The Utility says they are enjoying exceptional performance with this valve. No troublesome maintenance such as refacing valve seats or repacking stuffing boxes.

Independent seating and bonnet sealing set Crane valves apart from ordinary packless or diaphragm valves. The Crane diaphragm is used only to seal the bonnet—that's why it lasts so much longer. A "soft" insert in the disc face gives tight seating on the hardest-to-hold fluids, liquid or gas.

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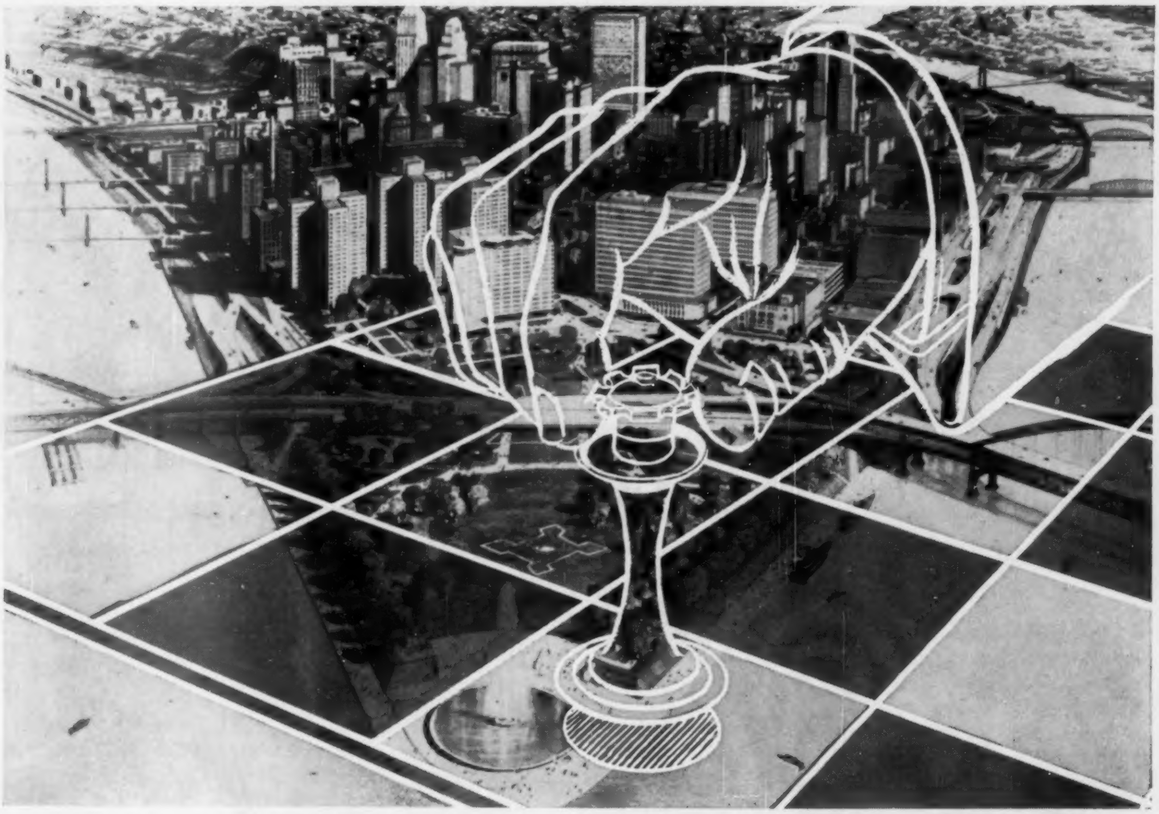

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Editorial

Arithmetic and the Atom

Early in April the Joint Committee on Atomic Energy is scheduled to hold its hearings on Senator Albert Gore's bill proposing a federal reactor construction program. The motivating thought behind the bill is to maintain the lead of the U. S. in nuclear technology. There are, of course, different viewpoints on ways and means of attaining this objective and the major clash will occur over the effectiveness of our present program as against Senator Gore's.

Domestically our atomic energy industry in 1956 began construction or received contracts on a total of 59 new atomic reactors, including 29 power ones and 30 research and test reactors. Certain of these research and test reactors are slated for overseas which up to the moment establishes this nation and its atomic industry as the world's largest exporter of nuclear equipment and know-how. On the basis of this record the manufacturing industry feels it has physical facilities ready to handle any reasonable expansion in this activity. All that is lacking from their viewpoint is a sufficient economic incentive. The public utility industry similary feels itself ready and able to handle a reasonable development program but again with one major exception. That exception is a need for an indemnity statute to protect operators of nuclear installations against excessive public liability beyond the reach of commercially available insurance protection.

At the All Congress Banquet of the 1957 Nuclear Congress the foreign situation was outlined. Something of the hopes and aims of the Western European cooperative effort in the atomic power field, to be known as Euratom, was given. These hopes are truly prodigious and envision a goal of 15,000 megawatts installed by the end of 1967. The magnitude of this goal is quickly grasped when it is realized that the recently announced British plan for atomic power development calls for 5000 to 6000 megawatts by 1965 at an estimated initial capital cost of 2 billion, 573 million dollars at current prices!

Paul F. Foster, assistant general manager, international activities, U. S. Atomic Energy Commission, main speaker at the above mentioned All Congress Banquet, had some interesting information based on our own experience which he worked into his speech apropos Euratom's ambitions. We quote: "You will recall that when the AEC undertook its big expansion program a few years ago, we were fortunate in having all the money we needed and all the authority required to get the job done on schedule. At one time, we were spending over 100 million dollars a month; we had approximately 15,000 architects, engineers, and technicians working directly or indirectly on our program; our construction labor force reached a peak of 74,000; our construction efforts represented about 5 per cent of total construction in the United States, and we took approximately half of the entire American output of stainless steel piping."

These numbers Mr. Foster employed in describing the earlier AEC expansion program should prove cause for concern at the Joint Committee hearings. Unless or until the six Western European nations comprising Euratom can develop a nuclear industry of their own, Great Britain and the U. S. A. will be hard to put to meet their already announced plans and also carry Euratom's. To our way of thinking the Joint Committee should preface any action they take with an exercise in arithmetic. Once it is known how much can be accomplished and how long it would take with what facilities we now have, the Committee can better gauge its own desires and appraise ways and means of providing incentives to both manufacturers and the public utilities to meet any required accelerated expansion.

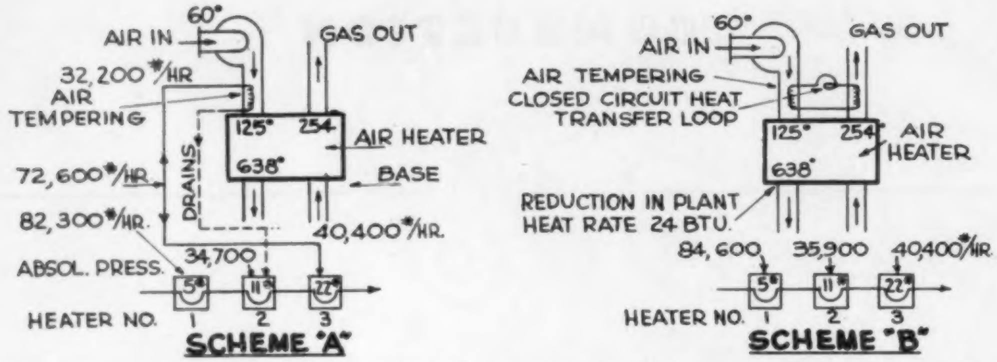


Fig. 1—Presented above in schematic fashion is the evaluation of the concept the author's company

Eddystone Supercritical Heat Cycle

The drive to achieve the maximum conversion of fuel energy into mechanical energy involves attempts at reducing the usual cycle heat losses at the condenser and the boiler stack ends. Here is an interesting try at interrelating boiler and turbine heat recoveries.

By SAMUEL M. ARNOW†
Philadelphia Electric Co.

IN the effort to obtain maximum conversion of the energy in the fuel into mechanical energy, the thermal cycle of power plants developed along two obvious paths. One method was to increase the spread between the initial and final enthalpy, the other was to reduce the principal heat losses at both ends of the system, namely the boiler and the condenser. In the first path, the lower end of the cycle is determined by the temperature of the heat sink which sets the limit for the expansion of the steam. To raise the upper end, one is forced to go to higher pressures, higher temperatures and multiple reheats; the limit being the metallurgical properties

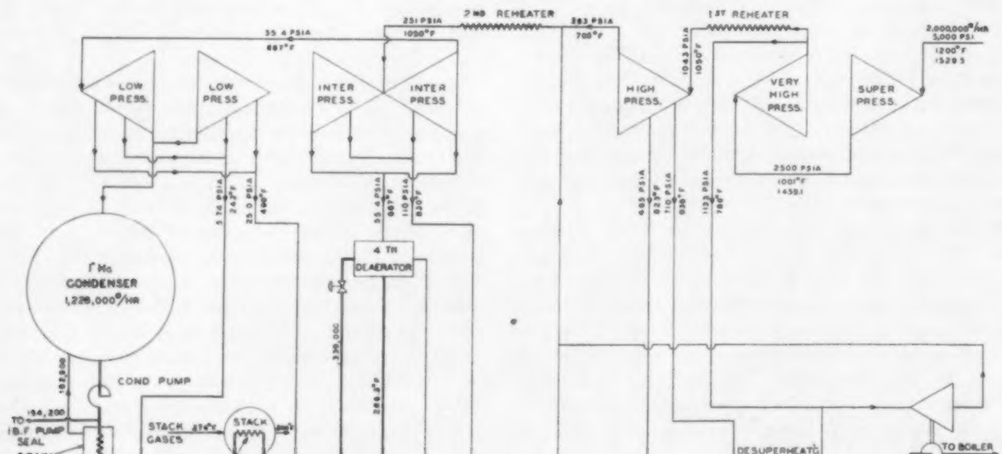
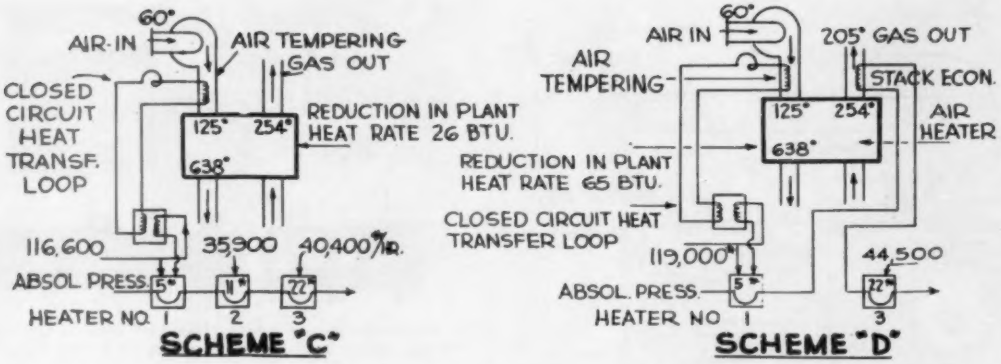


Fig. 2—Heat cycle diagram of the Eddystone Station shows low portion of cycle, with air tempering and gas cooling



employed in improving cycle heat recovery. Note the improvement in net heat rate from Scheme B to D.

Incorporates Stack Gas Heat*

of available materials and, of course, economics. The second path consists of making a thorough appraisal of the various losses in the cycle and then trying to eliminate them or at least reduce them.

Eddystone Station, with 5000 psi, 1200 F steam, nine stages of feedwater heating and two stages of reheat, may be taken as the acme of present developments along both of these paths. The loss of heat to the circulating water has been substantially reduced by expanding the regenerative cycle until the condenser flow is only about 62 per cent of the throttle flow, thus bringing the condenser loss down to less than 3450 Btu per kwhr. The reduction of losses at the boiler end has largely been a matter of lowering the exit temperature of the flue gases by means of economizers and air preheaters. However, when one attempts to carry this process too far, the cold end of the air preheater becomes subject to corrosion due to extremely low temperatures in the winter, and since the regenerative type of air preheater contains numerous small passages, they can get plugged up by sulfur-containing deposits. To prevent such troubles, the incoming air is preheated or tempered by steam withdrawn from the turbine. This, of course, represents a power loss in the turbine, but it is more than compensated by the possible increase in boiler efficiency which results from the ability to operate the boiler with lower exit-gas temperatures.

In all these improvements, the boiler and turbine were treated somewhat like two separate entities. It is the purpose of this paper to describe a system in which the boiler and turbine heat recovery processes are interrelated, with, it is hoped, beneficial results. Fig. 1 shows the evolution of this concept through its several stages: (1) using steam from the third bleed point to temper the air (2) employing a water loop to transfer heat from gas to air (3) taking steam from the first heater (4) adding a waste heat economizer to return stack heat back to the feedwater system.

* Presented before the American Power Conference, Chicago, Ill., March 27–29, 1957 under the title "Incorporating the Heat From the Stack Gases into the Supercritical Turbine Heat-Cycle at Eddystone Station."
† Senior Engineer, Mechanical Engineering Division.

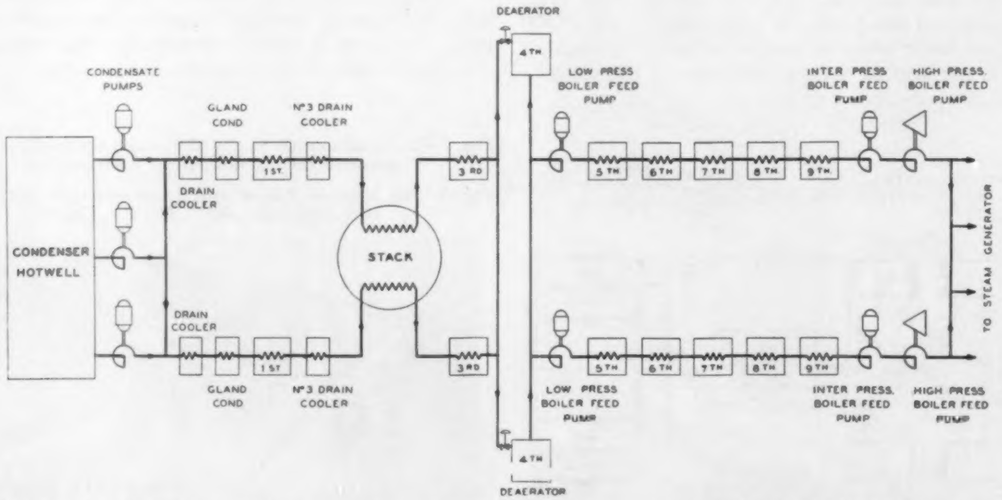


Fig. 3—Parallel feedwater heating system planned for Eddystone does not make use of individual heater by-passes

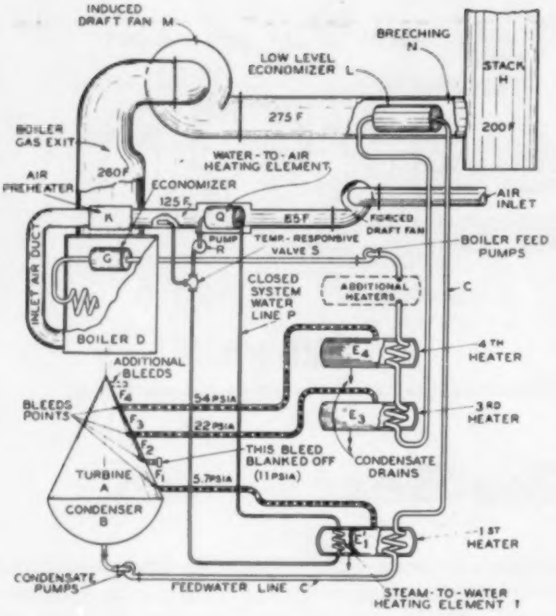


Fig. 4—The low pressure end of the heat transfer cycle shows above together with various equipment details. Note water-to-air heating demand and low level economizer

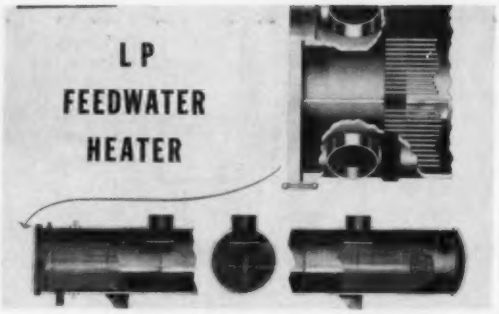


Fig. 5—Steam water heater has two sets of U-tubes, one for the boiler feed system and second for air tempering

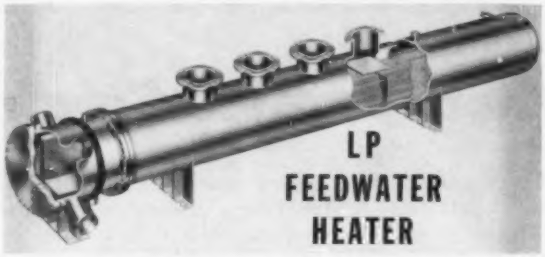


Fig. 6—Isometric view of heater in Fig. 5 shows steam inlets and infringement baffles as well as water connections

Fig. 2 shows the heat cycle diagram of this station. The low pressure portion of the cycle, in the lower left, indicates the air tempering and gas cooling arrangement. Fig. 3 shows the parallel feed heating system arrangement wherein there are no individual heater by-passes. Fig. 4 shows the pertinent equipment in greater detail. The system consists of, first, air tempering by steam from which the maximum possible energy has been extracted in the turbine and, second, of causing the flue gases to give up to the feedwater some of the heat remaining after leaving the last conventional heat recovery equipment in the boiler circuit. This scheme eliminates one of the feed heating stages thus allowing that steam to expand to the condenser. It also makes it possible to recover the heat developed by the induced draft fans. The net result of this scheme is a reduction of about 100 Btu per net kwhr which is equivalent to an increase of about $1^1/_4$ per cent in thermal efficiency of the plant.

Air Tempering Arrangement

Generally speaking steam used for air tempering must be above atmospheric pressure at all operating loads to prevent air from getting into the steam system and eventually into the condensate in case a leak developed in the tempering coils. In a reheat plant, cold reheat steam, being at a lesser enthalpy than any steam following the reheat point which would be above atmospheric pressure at partial load, is the best available for this purpose, although this results in a considerable loss of potential work. At Eddystone, however, steam from the lowest extraction stage of the turbine where it has given up the maximum heat to work and at a full-load pressure of five and one-half psia is used. This is made possible by interposing an auxiliary closed circuit water loop between the steam and the incoming air. This water is at a higher pressure than either the steam or the air, conse-

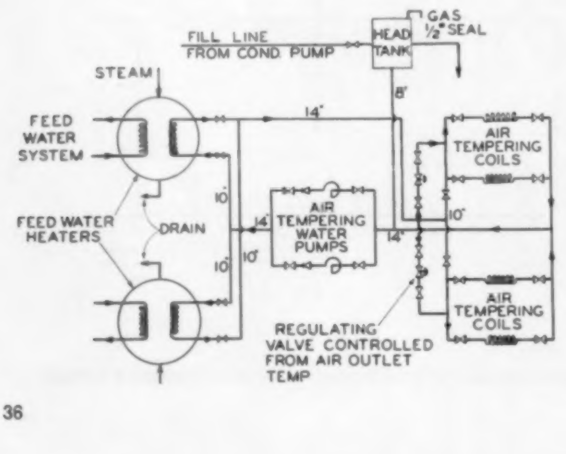


Fig. 7—Detailed sketch of the water and air heating circuit planned for the Eddystone Station, left

Fig. 8—Air heaters, below, have four separate sections of two elements each. See also Fig. 9

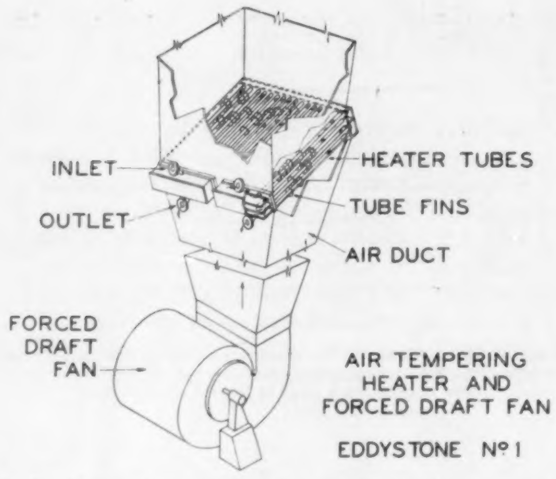
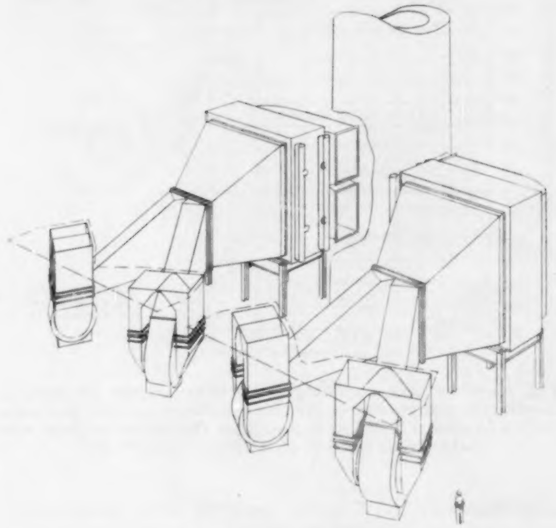


Fig. 9—The air heater of Fig. 8 is installed in the duct work leading from the forced draft fan, above

Fig. 10—The position of the economizers with respect to the stack is shown in the right



quently, no air can get into the system in case of a leak. The water loop has further advantage in that the rate of circulation of water in this loop can be varied so as to follow outdoor temperature changes and thereby regulate the amount of heat that can be absorbed by the air.

Fig. 5 shows the steam water heater used for this service. It consists of two sets of U tubes one to serve the boiler feed system, the other to heat the air tempering water. The heater has common steam and drain connections so that the problem of operating a feedwater heater shell and an air tempering shell in parallel is minimized.

Fig. 6 is an isometric view of this heater showing the steam inlets and impingement baffles.

Fig. 7 shows the water and air heating circuits in detail. As can be seen, the water heating system is common to the two parallel steam heaters and the two sets of tempering coils. This figure also shows the circulating pumps as well as the head tank and the fill system.

Fig. 8 shows the details of the air heater which is in four separate sections of two elements each. The water connections can, of course, be sectionalized.

Fig. 9 shows the heater location with respect to the forced draft fans. It can be seen that each fan serves a separate air heater section.

Low Level Economizer

While air tempering removes steam at a low stage in the turbine which would otherwise produce power, this loss is more than made up by installing a low level economizer to heat the feedwater. This allows the utilization not only of the heat remaining in the flue gas, but also absorbs the not inconsiderable heat from the induced draft fans. The steam which would normally be bled for this purpose is allowed to go to the condenser and since it is at a higher stage than that used for air tempering, there results a net gain of power in addition to the elimination of a stage heater. What is being done, is actually to replace low energy steam used for air tempering with steam of higher energy, which represents a fundamental cycle improvement. An added operating advantage is the fact that the economizer cold-end temperature remains practically constant at all times since the coolant enters it at a constant temperature of

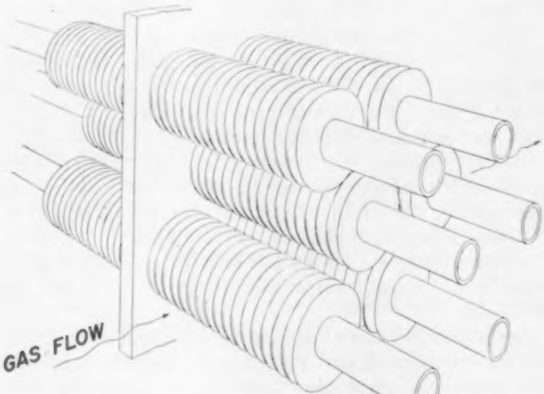
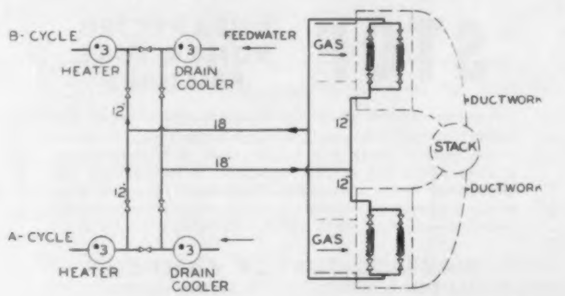


Fig. 11—Economizer tube details for the two economizers per boiler are given here, left

Fig. 12—The piping details for the feedwater connections to the stack economizer are laid out, below



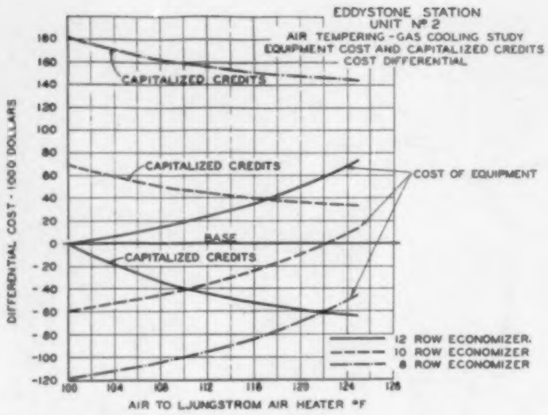


Fig. 13—Cost differentials present these curves for various leaving air temperatures for three distinct economizer sizes with a 12-row, 131,000 sq ft design as the reference base and outdoor air at 60 F, air to preheater at 100 F

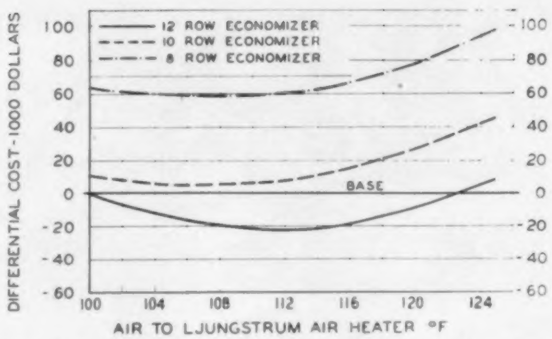


Fig. 14—Net cost curves for stack economizer combines cost of equipment and capitalized credit data of Fig. 13 to indicate 12-row back unit is lowest cost design

approximately 166 F at full load, the water temperature being determined by the load rather than by the outdoor temperature. Seasonal effects are thus eliminated and the installation operates under most favorable conditions. Fig. 10 shows the position of the economizers with respect to the stack. They are located after the precipitators and induced draft fans and are therefore handling the cleanest gases. Fig. 11 shows the details of the economizer tubes. There are two economizers per boiler, each being served by two induced draft fans. Each section is approximately 12 ft by 12 ft by 26 ft tall. The gas flow is across the tubes. They are made of 2-in. cor-ten tubes with 5-in. cast iron fins. The spacing between fins is 1 in., thus lessening plugging tendencies. This portion of the feedwater system is shown on Fig. 12 and it should again be noted that each element can be isolated, also the entire system can be by-passed.

A system of in-service washing will be installed. The frequency of washing will be determined by experience. One section will be washed at a time in order to concentrate the maximum amount of water during the wash period. It is hoped that because of the favorable operating conditions, the economizers can be kept in operation for a long time.

For Unit No. 2 at Eddystone, a study was made to optimize the temperature of the tempering air to the air heater as well as the size of the low level economizer. Three air temperatures leaving the tempering heater as well as three economizer sizes were studied, making nine cases investigated. All were based on 60 F outdoor temperature, with 100 F air to the preheater and a 12-row (131,000 sq ft) economizer as a base. Net Btu rate changes, capacity changes, auxiliary power requirements and other criteria were determined and capitalized and balanced against differences in cost of equipment. The resulting curves are shown on Fig. 13 where cost differentials are plotted against various air temperatures. As may be expected, for a given gas cooler, differential cost goes up as air heating requirements increase. On the other hand the various capitalized savings also increase, hence the available credit increases. When these curves are added, the resulting net differential cost curves show the optimum combinations. Fig. 14 shows these curves, and it turns out that for this job, 112 F air temperature to preheater and a 12-row (131,000 sq ft) stack economizer shows the lowest cost with respect to the base. Equipment of these sizes will, therefore, be installed.

The author wishes to thank all Westinghouse, Combustion Engineering and Philadelphia Electric personnel who helped to make the sketches and generally contributed to this paper.

The year of 1957, the author believes, should be a historical milestone for the transportation industry. It will herald the first commercial conveying of coal a long distance other than by wheeled vehicles or by vessels. The conveyor in this case will be the much discussed pipeline from Georgetown, O., to Cleveland Electric's Eastlake Plant. This method, it is felt, could well be used to transfer other bulk materials.

Fig. 1—The pipeline connecting Georgetown, O. cleaning plant of Pittsburgh Consolidation Coal Co. and Eastlake Plant of Cleveland Electric Illuminating Co.

Pipeline Transportation of Coal[*]

By C. A. DAUBER†

The Cleveland Electric Illuminating Co.

THE story of this particular project started in 1949, when the Pittsburgh Consolidation Coal Company realized that in order to retain their competitive position, cheaper means of transporting their product must be obtained. At that time, for hauls of 100 miles or more, freight rates were almost equivalent or greater than the charge for fuel at the mine. In addition, there appeared to be no end in spiraling transportation costs.

The Cleveland Electric Illuminating Company also had several problems. Coal could be carried by rail past the doors of its plants to nearby Lake Erie docks and loaded into boats at 38 cents per ton cheaper than it would be delivered into the plant yard. As a result, competitors up the Great Lakes are indirectly being subsidized by The Illuminating Company. Furthermore, companies with service areas nearer the coal fields are able to generate power cheaper and thereby undersell Northern Ohio utilities. Also, inflation was outrunning all cost saving measures which could be adopted. This portended an undesirable rise in electrical rates.

Research and Development Program

The Pittsburgh Consolidation Coal Company realized they already had been operating equipment which could furnish an alternative. It was embodied in a modern coal cleaning plant. The practice in many cases is to make a coal-water slurry, dewater and then dry. If the slurry preparation were kept at the source and the dewatering and drying shifted to the point of coal use, the additional equipment needed would be a longer pipeline in between for conveying the slurry.

In order to see if such a proposition were feasible, a small pilot plant was constructed at Library, Pennsylvania. It consisted primarily of a storage tank, a pump, and a short, small diameter pipeline which returned a slurry of coal and water back to the tank. After it was determined that such a method could be used, an installation was sought which would allow the operation under actual conditions.

The Pittsburgh Consolidation Coal Company, knowing that The Cleveland Electric Illuminating Company

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* Presented before the American Power Conference, Sponsored by the Illinois Institute of Technology, Chicago, Ill., March 27–29, 1957.
† Director of Civil and Mechanical Engineering.

would be interested in such a proposition and that they had an almost ideal situation at their Eastlake Plant for the receiving end of such a pipeline, approached The Cleveland Electric Illuminating Company. This resulted in economic studies to determine whether such an installation was logical from the cost standpoint. The results were sufficient to indicate that there were good possibilities. This led to constructing a $2,000,000 pilot plant which would simulate the conditions of a pipeline between the Georgetown Cleaning Plant of the Pittsburgh Consolidation Coal Company and the Eastlake Plant of The Cleveland Electric Illuminating Company.

This pilot plant consisted of many of the components required in a complete installation and the necessary equipment to pump a coal and water slurry of 108 miles. This verified mechanically that such a method of transportation was possible. From the results obtained with this second large pilot plant, the economics were again calculated. They proved that there were possible big savings with such a method.

In order to verify the results of the study, the data were given to an experienced engineering firm. They in turn concurred. This led to an agreement between the Pittsburgh Consolidation Coal Company and The Cleveland Electric Illuminating Company to have such a line built.

Other Pipelines

It will not be the first time that a pipeline has been used to transport solids. Back in 1889, Wallace C. Andrews, founder of New York Steam Corporation, actually built a pilot installation which in many ways was the duplicate of the one being proposed. This pilot plant was constructed in New York City, and was operated for a period of time. Mr. Andrews was very pleased with the results and stated that it had great possibilities. Unfortunately, it never resulted in an actual commercial installation.

In France there is a short pipeline, approximately seven miles long, which is used to convey coal from a coal cleaning plant to a power plant. Many of the components in this line are similar to the one from Georgetown to Eastlake. The main variation is that the flow depends primarily upon gravity, whereas in the one being described, it is accomplished by pumping.

Many of the companies being represented at the Conference have been pumping ashes for a long period of time. It has been one of the successful and most economical ways of removing this by-product from the bottom of the boilers to a point of disposal. The writer still remembers other experimental work in connection with pumping a coal and oil slurry.

Description Pipeline

There are three main parts to a coal pipeline. The first is the Preparation Plant, the second is the Pipeline including its Pumping Stations, and the third is the Dewatering and Drying Terminal.

Location of Facilities

The preparation plant is located at Georgetown, Ohio. Centered here is the large coal cleaning plant which serves the many mines of the Hanna Coal Division of the Pittsburgh Consolidation Coal Company. This is an ideal site because of the quantities and long time reserves of coal available at this one location. The pipeline follows a northerly direction from this cleaning plant as shown in Fig. 1. In addition to the initial pumping station at Georgetown, there are two stations enroute. The second pumping plant is located at Carrolton, approximately 30 miles north of Georgetown, and the third, at Atwater, Ohio, which is again approximately 30 miles north of Carrolton. The dewatering and drying plant is located on the site of the Eastlake Plant of The Cleveland Electric Illuminating Company in Eastlake. It is the most modern plant that the utility company has. It has an aggregate capacity of 660,000 kilowatts. It consumes approximately one and a half million tons of coal a year.

The main source of coal at the Georgetown cleaning plant are the fines which come from the Deister tables. Approximately 80 per cent of the coal which will be pumped is from this origin. The clean slurry coming from the Deister tables is pumped to the preparation plant of the pipeline.

Source of Water

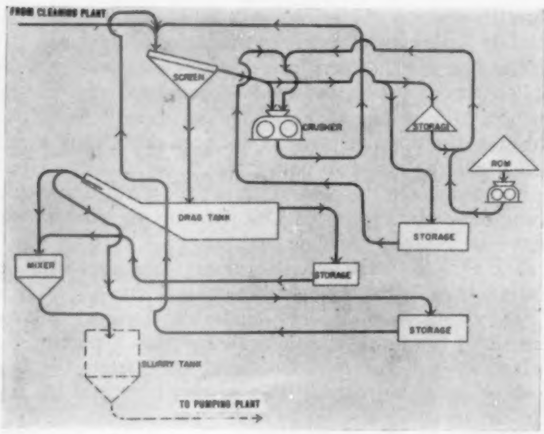
A large constant quantity of water is required in the transportation process. Several alternatives were studied to find the most economical source. The studies resulted in increasing the capacity of an existing lake by raising the dam height. The lake now contains six months' supply. It retains the surface water of a large area primarily owned by the Pittsburgh Consolidation Coal Company.

Preparation Plant

The principal parts of the preparation plant are crushers, screens, storage tanks, drag tank, and the slurry-mixing equipment. The arrangement is shown in diagram on Fig. 2. The fine coal pumped from the cleaning plant drops on to screens. The size going through the screens is suitable for the pipeline slurry, and passes into a drag tank. The oversize coal is carried to the crusher where it is reduced to the proper dimensions or it is conveyed to a storage pile. The product from the crusher can either be returned to the drag tank or put in a storage pond. The run-of-mine coal required to make up the deficiency between total needed and the Deister fines is crushed and then sent to the first crusher for further reduction in size before proceeding to the sizing screens. The coal going through the sizing screens will all pass through a 14 mesh screen.

The coal in excess of pipeline requirements can be directed to any one of three storage ponds. The first storage pond takes any fine which overflows from the drag tanks. The second pond is for the excess product from the drag tank discharge. The third pond is for storage of the oversize particles from the screens. The reason for storing the different sizes separately is to minimize segregation which would occur if all fractions were sent to the same pond. Also, the different sizes can be recombined in the same ratio as existed in the feed to the tank. Furthermore, this arrangement allows the reduction of the oversize particles without feeding all coal through the crushers.

The purpose of the storage ponds is to permit continuous operation of the pipeline when the cleaning plant is out of service. The pipeline will operate on a 24-hr, seven-days-a-week basis, whereas the Georgetown



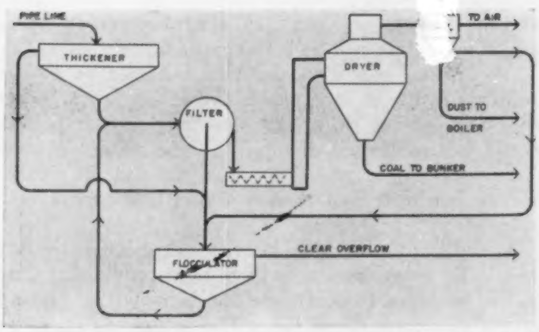


Fig. 2—Arrangement of the principal components of the preparation plant can be seen on the left

Fig. 3—Simplified diagram of dewatering and drying plant, above, indicates type of equipment employed

cleaning plant is on a two or three-shift operation, five days a week. As a result, the preparation plant was designed for 300 tons per hr, whereas the pipeline requires only 150 tons per hr. It is the difference, or the excess, that must be stored.

In order to insure the proper slurry concentration, 50 per cent by weight coal and 50 per cent water, the discharge from drag tanks is processed in a mixer. At this point, automatic equipment continuously measures the mix and adds the proper amount of water.

Pumping Stations

The slurry from the mixer is pumped to the suctions of the pumps in the initial pumping station. There are three pump units at each of the three locations. Each unit consists of a Wilson-Snyder reciprocating pump driven by a 450 hp squirrel cage motor connected through hydraulic couplings and a speed reducer. Two of these pumps are required to supply the total requirements of the pipeline. Each will pump approximately 530 gpm of slurry which has 306 gallons of water in it—the balance being coal. These pumps are capable of discharging the slurry at 1000 psig pressure. The discharge from each pump goes to a single surge tank. This surge tank feeds directly into the pipeline.

The two booster pumping stations enroute are typical of the Georgetown pumping plant except for the reservoirs at Carrolton and Atwater. The latter will have two each, one for storing an emergency supply of water and the other for emergency dumping of slurry. The water will be pumped from wells at each site.

The purpose of the hydraulic coupling is to insure automatic compensation for pump wear. The third pump is a standby for maintenance which will be done when the volumetric efficiency of anyone drops below 80 per cent. These particular pumps are constructed for ease in disassembling and the layout of the pumping plant is such to minimize the time required for maintenance. The pumps were primarily built for handling solids and are used extensively in forcing "mud" into oil well drill bits. Provisions have also been made to minimize stoppage of flow. Controls will automatically bypass any of the booster stations having a power failure and the preceding station will be adjusted to carry the additional burden.

Editor's Note: The map of the pipeline course, Fig. 1, p. 39, identifies Cadiz, O. as site of the first pumping station referred to above as at Georgetown.

Pipeline

There is a single pipe leading from each of the pumping plants. It is a $10^3/_4$-in. O.D. steel pipe with all welded joints. The wall thickness depends upon the location as the pressure becomes lower as it proceeds through the pipeline. The thickness does not exceed 0.7-in. The entire pipeline is buried below the frost line being some four to five feet under the surface.

Inasmuch as it goes over hilly terrain, it was necessary to limit to a maximum inclination. If the pipeline were too steep, the coal would have a tendency to roll back even though the water continued on its path. The maximum inclination permitted was 10 degrees.

The velocity in the 108-mile line will be approximately 4.5 ft per sec. The time lapse from the point of introduction to delivery will be over thirty hours. Pilot line operation indicates that no harm will be done if the pumps fail and the velocity of the slurry drops to zero. It was found in the pilot system that even though the coal will drop to the bottom of the pipe, it will not compact. The increase in the water velocity caused by partial blocking of pipe by the coal when flow is restarted is sufficient to turn the coal and water into a slurry.

Erosion

A question usually raised is: "Won't the erosion be excessive and cause rapid wear?" It is true that some erosion will take place; however, it will not be to the degree usually expected. There are several reasons for this. One is that the coal will be much cleaner than that normally handled; it is the ash and silt that is excessively erosive. Also, coal itself has greasy qualities. Another phenomenon is that the erosion decreases after it is pumped a short distance. The reason being, the attrition wears off the sharp corners and finally the particles become spherical. This has been proven with other slurrys. Nevertheless, twenty years of wear material were added to the thickness required for pressure and safety.

Corrosion

A problem which is as great or greater than erosion, is corrosion. This corrosion could occur either on the exterior of the pipe or the interior. The exterior corrosion is normal to any pipeline. This is minimized by an enamel coating reinforced with glass cloth over the

exterior surface. In addition, after a period of operation, the pipeline will be given cathodic protection.

The interior corrosion could be initiated by two ingredients in the slurry; one is the acid solution formed by water leaching sulfur compounds from coal, and the second is the oxygen dissolved in the water. Anyone having experience where water is drained off either a storage pile or a coal bunker knows how corrosive the liquid is.

In order to minimize interior corrosion, means to chemically treat the slurry have been provided. Caustic will be added to neutralize the slurry. The goal is to have a minimum pH of 6.5. The action of oxygen will be arrested by introducing an inhibitor into the slurry. In addition, nitrogen will be used in the surge tank heads. The treatment will be added at the three pumping points because better control will be accomplished by doing it this way rather than at one source.

Dewatering and Drying Plant

Figure 3 shows a simplified diagram of the dewatering and drying plant. Two 90-ft diameter Dorr thickeners initially receive the coal from the pipeline. The coal falls to the bottom of the thickeners and the water decants over the rim of the tank. The water flows to a flocculator. The flocculator has a center section in which paddles rotate at a very slow speed. The gentle motion imparted to the decanted liquid which will contain approximately 100 ppm of solids, tends to make the solids agglomerate. To assist this operation, an agglomerator will be added. The enlarged coal particles eventually float out into the outer section of the 85-ft diameter tank and gradually drop to the bottom. The overflow from the flocculator, approximately 525 gpm, is conducted to a discharge canal of the power plant. The overflow will have approximately 10 ppm of solids. In addition to the agglomerator, a chemical will be introduced into the clarriflocculator in order to maintain a maximum of 1 ppm of chromate in oxygen inhibitor in the overflow. The plant discharge canal normally has an outflow of 400,000 gallons of circulating water per minute and will assist greatly in diluting the effluent from flocculator.

The sludge from the Dorr thickeners and clarriflocculator is pumped to vacuum disc filters. It is estimated that this mixture will be 42 per cent by weight water, and 58 per cent coal. The coal cake formed on the filter discs will have approximately 20 per cent water in it; however, this is still too wet to process in the power plant.

In order to reduce the moisture further, there are four flash dryers. Each two dryers are furnished warm air from a special furnace. A portion of the coal supplied to the plant, approximately 3 per cent, will be burned in the furnace in pulverized form. The heated gases leaving the furnaces will be tempered with room air and sucked up into one of the two drying columns. These columns are approximately 3-ft diameter and 65-ft high.

The filter cake is fed into the bottom of the columns and is picked up by the gas being drawn up through the columns. A large portion of the moisture in the coal vaporizes and mixes with the heated gases. The gas and coal mixture from each drying column is directed into a cyclone collector. The heavier coal falls into the bottom of the collector and the moist gases go out through the top. The coal will be reduced to approximately 5 per cent moisture in the latter operation.

The hot gases drawn from the dryer cyclone will be pulled through a second cyclone collector system, and thence to a water washer. The gases will be drawn through the arrangement by induced-draft fans which will discharge into two power plant stacks. The effect of reduced ash in the coal will bring the solids discharged from these stacks down to 65 per cent of what it was previous to use of pipeline coal.

The coal from the initial cyclone separators will discharge to a belt conveyor which will convey it to a 1200-ton surge bin. The weight of the coal will be measured by an automatic scale forming a part of the belt conveyor system. The coal dust from the secondary collector will be used primarily to fire the hot air furnaces.

At eight-hour intervals, the coal from the surge bin will be fed on to the 1200-ton per hr conveyor system, which will take the dryer plant coal to the plant coal storage bunkers. The surge bin is required so that the main conveyor system need not operate continuously.

Eastlake Plant Coal Requirements

The coal pipeline will furnish approximately 80 per cent of the coal burned in the power plant. The additional coal needed will be brought in either by truck or rail. It is estimated that 1,250,000 tons a year will be delivered by the transportation system described.

The product from the pipeline will be very fine. Although coal does have a tendency to agglomerate in large particles as it passes through the dryers, it does not take much pressure to crush the agglomerated particles. Inasmuch as the granules of coal are very fine, there is no intention, at present, to store pipeline coal. The samples taken from the pilot plant were such that a high wind could easily blow a large amount away without too much difficulty.

The existing 400,000-ton pile will be maintained for emergency purposes until considerable experience has been obtained on the reliability of the pipeline system. In addition to the storage pile at the plant, there will be 100,000 tons of storage capacity at the preparation plant. This is to provide first, as mentioned previously, for the normal closing down of the Georgetown washing plant, and secondly, any stopping of operations at the washing plant.

Economics

The total cost of the project will be approximately $\$12^1/_2$-million. About $\$2^1/_2$-million of this amount went toward constructing the dewatering and drying terminal. The actual construction costs approximated the original estimated figures. The entire project is owned by Pittsburgh Consolidation Coal Company. They will operate and maintain the preparation plant and pipeline. Operation of the dewatering and drying facilities will be the responsibility of The Cleveland Electric Illuminating Company.

In calculating what the cost would be to ship coal by pipeline, 15-year amortization was used. All the factors such as cost of money, taxes, insurance, are fully charged. The use factor for the system is expected to be at least 90 per cent. The net result was a substantial savings when compared with the present railroad tariff

of over $3.30 per ton from the Georgetown cleaning plant to the Eastlake Power Plant.

The savings should be greater than anticipated in the original studies. The main reason is that all the equipment are substantially oversize. There is no doubt that some of the oversizing will result in being able to transport a greater amount than used in the calculations. This can be done at low additional cost. Also, a substantially large portion of the pipeline costs are fixed as compared to railroad costs and future increases in labor component will have less effect.

There are several other advantages and disadvantages with shipping coal by this method. One of the advantages to the supplier is a long-term steady consumer. In this particular case, he is assured of a definite amount for a 15-year period. This will allow him to plan his mining operations better, and make use of cost-saving equipment. The disadvantage to a supplier is that he is furnishing a single source with a large portion of his product. The receiver has the disadvantage of less competition by coal suppliers.

The contract required in such a relationship is very complicated. In order to be fair to both parties, a basis for adjusting costs and prices must be established. Factors must be taken into account such as variations in cost, labor, materials, supplies, taxes, and insurance. This must be done through escalation clauses. The parties to such a contract must deal in good faith because the factors involved are so complicated.

Summary

Although the transportation of coal by pipeline will be expanded in the future, it will not serve all requirements. The conditions must be ideal in order to be competitive. In the first place, the quantities transported must be large to break even. If the amount would be greater than supplied to the Eastlake Plant, the per ton savings would be of a much larger magnitude. The reason for this is that the initial cost and operating and maintenance expenses would not increase in proportion. Furthermore, many of the facilities supplied could be used for a system having many times the capacity.

In most cases, it would not pay to ship the material by this means to a central disposal point and then by another manner to other localities unless the savings are much greater than for this particular system. The additional handling costs would overcome any advantages.

There may be possibilities such as using a tanker to convey the thickened slurry from pipe terminal to point of use.

If normal transportation costs are proportional to the distance shipped, the potential savings by pipeline will be greater. The preparation and dewatering facilities are the same regardless of the length of the line. The line and pumping equipment would be components having increased costs.

If the power plant had been built especially to burn the new product, the savings would have been greater. Some equipment is capable of burning coal from such a line without pulverizing. In addition, the hot air furnaces could have been eliminated, if original plans would have allowed use of power plant stack gases in flash dryers.

The pipeline should be successful from the mechanical standpoint. This statement is based upon the fact that although the arrangement of the equipment is revolutionary, each individual unit has been used with good results in other processes for long periods of time. This equipment can be found in modern coal cleaning plants, chemical plants, water-treating plants, and sewage-treating plants.

The overall summary is that the pipeline transportation is here to stay if present freight rates are maintained. There will be a larger number in the future. Many will be used to convey a variety of bulk materials. It will be a major factor in being able to serve electric customers with "Better Service Cheaper."

Acknowledgements

The author wishes to express his appreciation for the assistance given by Mr. Victor Hanson, Chief Mechanical Engineer of Pittsburgh Consolidation Coal Company, and Mr. Gordon Walker, Senior Project Engineer of The Cleveland Electric Illuminating Company. Both contributed extensively to the paper.

American Power Conference in Review—I

The nineteenth annual meeting of the American Power Conference was again held at the Sherman Hotel in Chicago, March 27–29 inclusive. Registration was excellent with some 2800–2900 signing in.

Dr. Walter H. Zinn, former director of Argonne National Laboratory, was presented with the Conference's Certificate of Merit, the second such aware in the Conference's history, for his contributions in the field of nuclear power generation and atomic research. Zinn was a member of Dr. Enrico Fermi's group at the University of Chicago at the time of the construction and operation of the first nuclear chain reacting pile.

The opening luncheon featured as its speaker, **Donald S. Kennedy,** president of Edison Electric Institute, speaking on the subject, "Electricity and Progress". Mr. Kennedy's remarks lauded the privately-financed utility companies which had brought into being a growth in capacity of 100 fold in a 50-year period. This capacity growth he held to be truly remarkable and a continuing accomplishment with about 4.5 million kw installed in 1956, an estimated 6.7 million kw additional for 1957 and by 1961 around 29.5 million kw on order with manufacturers. The capital growth of these same privately financed companies has risen from $1 billion to more than $30 billion in a 50-year span.

Assistant secretary of the Interior, **Fred G. Aahndal,** also a luncheon speaker, covered "The Electric Utility Industry in Civil Defense". The Department of the Interior, Mr. Aahndal explained is responsible for plans for electric power preparedness to protect citizens in war. Because the weapons that could be unleashed are so powerful Mr. Aahndal recommended that the utilities should institute certain precautions, such as: (1) have adequate security plans (2) train employees in radiation detection (3) store equipment in widely separated areas (4) have more than one emergency headquarters and dispatching center (5) have communication with neighboring power systems (6) establish liaison with local civil defense director and coordinate all plans with him.

At the main banquet, the All Engineer's Dinner, **Gwilym A. Price,** chairman and president of Westinghouse Electric Corp., chose as his topic "Our Mutual Stake in Industrial Research." The United States will spend in total about $6.3 billion in 1957 for industrial research and development. For their part the electrical manufacturers are spending either for their own projects or contract projects about six per cent of their sales income on research and development programs, according to Mr. Price. This figure is high and stands second among all industries. But the remarkable part of this research program, in the speaker's opinion, is that much of it is being carried out on a partnership basis between two segments of the overall electrical industry—the manufacturer and the utility.

The research dollar was held to be the most valuable one in America today for it is the research dollars of the 1920's and early 1930's that have given new life to today's electrical industry. Luminescent lighting and central station nuclear power are prominent examples. Should today's research prove as productive in the future they will result in a series of developments greater even than those known today.

Gas Turbines

The gas turbine as could be expected came in for considerable discussion. One very well-developed theme was the gas turbine in the power plant.

A. R. LeBailly and **L. Skog, Jr.**, Sargent & Lundy, combined to present the paper "Design and Characteristics of a Combined Gas and Steam Cycle of 40,000 Kw Capacity." Their introductory remarks quickly identified the gas turbine's contribution to plant efficiency in the way of higher permissible inlet temperatures than steam turbines can offer. The larger temperature drop in the working fluids carries with it a significant gain in theoretical efficiency. In addition the gas turbine has proved a reliable performer. While the efficiency of the simple gas turbine is lower, its quick starting characteristics make it more suitable for operation for seasonal and peak shaving loads. The greater efficiency of the combined gas-steam cycle, the authors stated, would justify sustained operation of a gas turbine in conjunction with a steam turbine and the combined heat rate would be comparable to a steam cycle of higher pressure and temperature design. This paper described the design and characteristics of an application of a combined cycle to an existing gas turbine at the Rio Pecos Power Plant of the West Texas Utilities Co.

The growth of electrical load in this area necessitated the addition of larger new generating capacity. The management recognized that the present obsolete steam plant, now tied to a gas turbine cycle, would operate in the future only during the summer months and they wished to explore the benefits of combining the existing gas turbine cycle and the proposed new steam plant extension.

A number of plans were studied and finally it was decided to develop a gas-steam cycle with gas turbine exhausting as the combustion air supply. It was calculated that the exhaust of the gas turbine would supply the required oxygen to support combustion on the gas-fired boiler for loads up to 33 Mw. At these loads, the gas inlet temperature to the gas turbine is approximately 1450 F and the exhaust 844.5 F. Using natural gas fuel with a heating value of 750 Btu per cu ft, the oxygen content of the turbine exhaust will be approximately 17 per cent. The maximum flow of 351,000 lb of exhaust gases will support combustion of 27,090 lb of supplemental gas fuel to the boiler burners with 8 per cent excess air. The corresponding steam generation of 289,000 lb per hr generates 33 Mw on the steam turbine.

Beyond this steam turbine load it will be necessary to supply additional air which will be provided by a conventional forced draft fan.

This installation of the gas-steam cycle with turbine exhaust as combustion air will be one of the first in a public utility of a new gas turbine and offers the following advantages: (1) increase of combined efficiency 7.4 per cent over the conventional four-heater steam cycle; (2) slightly lower overall plant investment; (3) retains a high load factor on the comparatively new gas turbine; (4) the boiler closely resembles a conventional unit and does not require the development of new design or untried components.

A second paper, not on the same session, however, but of direct interest to the subject was entitled "Industrial Application for Combined Gas Turbine-Steam Plants," by **W. B. Wilson,** General Electric Co. In this paper Mr. Wilson opened with the conviction that industrial plant management is becoming more aware of the important part power and steam play in the economic operation of their plants. Though not a large per cent of total production costs, steam and power add up to a large annual dollar cost and management recognizes the economies that can be realized by more careful planning of the power and steam supply. From the data presented in this paper, the author felt certain all would recognize that:

(1) There are many applications where a combination of gas turbines and steam turbines will be more economic than either type of prime mover alone.

(2) Combustion gas turbines with supplementary-fired exhaust-heat-recovery boilers can supply the varying quantities of power and steam, at any pressure required, in our industrial plants.

(3) Users, consultants and process engineers are finding many applications where the gas turbine plant can most economically supply their requirements for power and steam.

The first gas turbine–supplementary-fuel-fired exhaust-heat-recovery boiler combination, the author reported, has recently gone into operation at a plant of the Gates Rubber Co. This is the first gas turbine operating to supply power, heat and oxygen—heat and oxygen in this case being highly preheated combustion air for a steam boiler.

In this plant, the gas turbine with its supplementary-fired exhaust-heat recovery boiler is supplying approximately 5000 kw of electric power and 120,000 lb per hr of steam for power or process use. It supplements the output of power and process steam from an existing steam turbine power plant.

The application has been described elsewhere but, basically, the turbine and boiler components are arranged for operation at any pressure desired between the 200 to 300 psig process level and 450 psig, the initial pressure of existing steam turbine power plant. Operating at 450 psig, this boiler can supply or augment the supply of steam to the steam turbines when required, such as when one of the normal fuel-fired boilers is out of service for inspection. The gas turbine exhausts highly preheated combustion air direct to the boiler during normal operation. Forced or induced draft fans are not required to provide a separate supply of combustion air because the turbine exhaust is rich in oxygen. A forced draft fan was, however, provided in this installation to supply combustion air at any time it is desired to operate the boiler when the gas turbine is out of service for inspection.

Based on this plant's requirement for 5000 kw plus 120,000 lb per hr of 250 psig steam, fuel chargeable to power with a gas turbine would be approximately 30 per cent less than for a 600 psig, 750 F steam turbine plant, Mr. Wilson claimed. Performance of the steam turbine plant could be improved by use of higher initial steam conditions. Even so, when the requirement is for 450 psig steam, fuel chargeable to power with a 1250 psig steam turbine plant will still be higher than for the gas turbine. A requirement for high pressure steam is a condition favorable to the gas turbine.

The gas turbine most often used for application in industrial plants is the simple-cycle, single-shaft unit consisting of a compressor, a combustion system and a turbine. Air flow is almost 5 times that actually required for combustion of fuel burned in the turbine. This leaves much unused oxygen in the turbine exhaust that can be utilized for the combustion of additional fuel. This excess air is necessary to maintain turbine inlet temperatures within limits and, of course, to add mass flow required to power the turbine. Depending on the cycle, gas turbine exhaust temperature ranges up to 800 or 900 F.

The gas turbine can then supply at least four useful outputs. They are (1) shaft power—for generator or mechanical drive, (2) heat—recovered from the exhaust for various uses, (3) highly preheated combustion air, and (4) compressed air.

Exhaust from a 5000-kw simple-cycle gas turbine can generate 35,000 to 40,000 lb of process steam per hour in a simple, exhaust-heat-recovery boiler. With unfired exhaust-heat-recovery boilers, a ratio of 6 to 8 lb of steam per kilowatt-hour is a reasonable steaming capacity to assume for boilers recovering heat from the exhaust of simple-cycle turbines.

If a boiler is to be installed to recover sensible heat in the turbine exhaust, the added flexibility and steaming capacity available by making the boiler suitable for fuel firing should not be overlooked. Because of the excess

air available in the gas turbine cycle, exhaust from the gas turbine contains approximately 17 per cent oxygen compared to 21 per cent for free air. This exhaust can be utilized as combustion air for additional fuel firing in a supplementary-fuel or straight-fuel-fired boiler when more steam is required than can be regenerated from the hot exhaust alone.

A fuel-fired exhaust-heat-recovery boiler is selected when it is desired to make maximum use of the oxygen available in the gas turbine exhaust.

For the unfired boiler, practical limitation on maximum steam pressure is approximately 200 to 250 psig saturated if operation over a wide range of turbine loads at constant speed is anticipated. Somewhat higher steam conditions would be practical where turbine speed is reduced or when a two-shaft gas turbine is considered.

By the addition of fuel firing, a boiler for any steam condition normally used in industrial plants can be selected as required for most economic overall plant operation. In addition, controls can act to automatically vary the amount of fuel fired in the boiler to cover a range of steam flow requirements independent of the load on the gas turbine or the ambient temperature.

The use of a gas turbine to supercharge a steam boiler is another efficient method of utilizing the gas turbine. In this combination, the gas turbine combustion system is removed and the air leaving the compressor is introduced directly into the boiler where all plant fuel is burned. The hot, pressurized gas is discharged from the boiler, after generating steam, and expands through the gas turbine. This turbine provides the power to compress the air, and, depending on the turbine-inlet temperature, residual power to drive a generator.

Power output from the gas turbine may actually be as much as 10 to 20 per cent higher when used in a supercharged boiler arrangement than when operated as a straight gas turbine with its own combustion system. The reasons for this are:

(1) Pressure drop in furnace is lower than in gas turbine combustors and therefore higher pressure gas is available for expansion through the turbine.

(2) Increased gas flow is available for expansion through turbine because of the additional fuel fired in the gas between the compressor and the turbine to generate steam.

(3) Additional energy is available, per pound of gas flow, because of the increase in specific heat of the gas when it contains more products of combustion.

E. L. Daman, Foster Wheeler Corp., and **E. L. Richardson,** General Electric Co., collaborated in the report "Economics of Medium Sized Supercharged Power Plants." This paper dealt, from the standpoint of performance and investment, with the economic comparison of a gas turbine supercharged boiler and steam turbine plant having a rating of about 45,000 kw with comparable conventional steam plants.

While modifications of heat-reclaiming devices to suit individual cases are possible, a typical supercharged cycle for a plant with 45,000-kw rating was shown. This cycle employed a 2-shaft simple cycle gas turbine which is an available standard design, except that a supercharged boiler had been substituted for its combustion system. The boiler surface was designed to reduce the gas temperature leaving the boiler to 1450 F for use in the gas turbine and steam was generated at any desired pressure and temperature for a 40,000-kw tandem compound, double flow condensing steam turbine unit.

Combustion gas from the boiler at 1450 F was passed through the gas turbine and exhausted through the economizer and stack gas cooler at 300 F to the stack. The steam turbine used a conventional regenerative cycle except that a stack gas cooler was substituted for one intermediate heater.

The illustrations and the load performance curves the authors employed were based upon the earlier ones appearing in a paper by **J. W. Mann** entitled "Thermodynamic Performance and Design of Steam-Gas Turbine Power Plants," American Power Conference, 1956.

The studies indicated that supercharged plants of smaller rating than 45,000 kw are entirely practical and will show excellent gain in heat rate when compared with conventional plants of comparable rating. At the lower ratings a premium in cost per kilowatt would be expected for the supercharged plant over the conventional plant.

The calculations for plants with ratings below 45,000 kw have been made using the same gas turbine and a boiler with the same furnace volume as that for the 45,000-kw plant, but with reduced boiler and economizer surface. Reduction in rating was accomplished by increasing the percentage of excess air to the boiler. If, for the lower ratings, normal excess air was maintained and the size of gas turbine and boiler were reduced in proportion to plant rating, the cost of these components would be reduced and the economics for the lower ratings improved.

The gas turbine and supercharged boiler, the authors maintain, offer an economical means of steam generation at any pressure and temperature and for use either for generation of power or process steam or both.

The wide variety of steam turbine designs for condensing or noncondensing service with single or multiple automatic extraction points permit consideration of the supercharged cycle by large industrials or utilities supplying steam to their customers for process and heating loads.

The authors stressed that it should be understood that the supercharged cycle lends itself just as readily to large power plants as it does to the small power plant which is discussed in this paper.

A comparison of heat rates for a 45,000-kw supercharged plant when burning either fuel oil or natural gas was shown in tabular form as follows:

NET PLANT HEAT RATE

	Conventional Plant	Supercharged Plant	Per Cent Gain by Supercharged Plant
No. 6 oil	10491	9713	7.4
Natural gas	11163	10326	8.3

Central Station Steam

A four-paper session on steam practices for the central station field covered a wide range of activities.

The paper by **S. M. Arnow,** Philadelphia Electric Co., "Incorporating the Heat from the Stack Gases Into the Supercritical Heat Cycle at Eddystone Station" is reported in its entirety on p. 34 of this issue.

E. M. Powell, Combustion Engineering, Inc., selected "Operating Experiences with Twin Furnace Boilers." His opening comments sketched the acceptance of the controlled circulation principle for steam generator design and also gave an accounting of the features and operating advantages the principle holds forth.

Mr. Powell then gave the results of tests and operating experience in a number of twin-furnace installations. These included unit No. 4 at Eastlake Station of Cleveland Electric Illuminating Co. which after a shutdown to remove strainers from the turbine inlet was equipped with a number of thermocouples for superheater, reheater and steam drum measurements. Upon start-up gas temperature traverses were run. The test data compiled were then discussed. Certain other experiences were recounted for the Cromby Station unit of Philadelphia Electric Co.

The application and suitability of various pumps for controlled circulation service was discussed and specific installation experiences described.

D. R. Wilson, Babcock & Wilcox Co., in his paper, "Advances in the Field of Large Steam Generators," traced the development of higher pressure, higher temperature, larger capacity installations and in the course of his talk described the contributions of the cyclone burner to this development.

The trend into the supercritical pressure range as Mr. Wilson saw it, dictated the "once-through" design of steam generator since there is no density differential between steam and water for natural or controlled circulation. In a once-through steam generator the solids in the feedwater must either deposit out in the tubes or leave with the steam. Therefore, a high degree of feedwater purity is required and condenser leakage or other conditions contributing to feedwater impurities cannot be tolerated. Pilot plant operation has provided knowledge pertinent to the precise limits on feedwater conditions for once-through boilers.

The control of once-through boilers is simpler than that of subcritical pressure units because one point of control, the drum water level, is eliminated. The steam pressure controls the feedwater flow, while the firing rate is controlled to maintain steam temperature.

Water Treatment

The field of water technology was accorded four separate sessions. The opening one of the four was given over to the subject of water softening processes. The presentation by **L. F. Wirth,** National Aluminate Corp., on "A Survey of Operating Plants, Problems and Successful Operation" is carried in its entirety on pp. 55 of this issue and deals with the hot lime zeolite method.

B. E. Varon, Richfield Oil Corp., supt. of utilities along with **S. B. Applebaum,** Cochrane Corp., described the experiences of the Watson Refinery of Richfield Oil Corp. in their paper, "An Application of Hot Lime Zeolite to Moderate High Pressure Boiler Operations." The particular applications were two hot process plants for 600 and 700 psi boiler plants both operating on the same water at the same time. The 600 psi installation employing a 56 per cent makeup used a single stage hot process plant without zeolite while the 700 psi unit working on a 60 per cent make up had a two stage hot lime zeolite plant.

Mr. Varon and Mr. Applebaum gave rather detailed data on the chemistry applying to both plants, the supplementary boiler treatment and the physical description of the softening equipment as well as amounts and costs of chemicals. In addition, the difficulties encountered with tube failures in the hot process system were advanced. Finally a number of comparisons were offered:

(1) Greater flexibility in the pretreatment and certainty of results. If the lime pretreatment should vary for any reason and, therefore, not reduce the hardness as low as desired, the hot zeolite removes all the residual hardness anyway.

(2) The economizer in the 700 psig plant required a feedwater extremely low in oxygen and hardness and high in pH value to avoid corrosion and scale. Preboiler problems of this type are practically non-existent with hot lime zeolite systems.

(3) Over two-thirds of the supplementary phosphate was saved because of the zeolite.

(4) The suspended solids in the boiler water is held much lower due to the negligible residual hardness in the zeolite effluent and the much lower amount of phosphate precipitate in the boiler resulting therefrom.

(5) Silica and magnesium are reduced to low values which greatly facilitate the maintenance of silica-phosphate relationships for prevention of adherent magnesium phosphate and the danger of complex silicate deposits.

(6) Lower alkalinity is maintained in the pretreated water by using more gypsum and this lower alkalinity reduces the free CO_2 in the steam.

(7) No zeolite resin has been lost or replaced after nearly three years of operation. It delivers an effluent containing less than 1.0 ppm of hardness as $CaCO_3$.

J. E. Harden, assistant superintendent, utilities division, and **Glenn R. Hull,** general foreman, utilities division, Whiting Refinery of Standard Oil Co. of Indiana, chose as their topic "Operating Experiences With a Large Hot Lime Zeolite System for 1500 psi Boilers." They opened by recounting the water treatment experiences at Whiting and the decision in 1953 to convert an existing hot lime soda phosphate plant to a hot lime sodium zeolite unit of 500,000 gal. per hr capacity with a $1^1/_2$ hr retention time in the softeners. Operation started in October, 1954 and all boiler feedwater used in the refinery has been furnished from this system since December, 1954.

The continuous and correct operation of the treating plant is of such importance that an experienced operator of the authors' highest paid non-supervisory operating group is assigned each shift. He directs the operation of the entire treating plant and does most of the operating of the zeolite portion of the plant. He is assisted, each shift, by two operators who are in a lower pay status. As pointed out the operation of the zeolite softeners can be done manually, semi-automatically or automatically. At first, the plant was run on manual control for several months. This was done, not only to adjust equipment and develop a satisfactory revised control cycle, but also to train the operators to run the plant manually. Since that time the plant has operated on automatic control for occasional short periods.

However, most of the time semi-automatic control is used. This means that the operator, not the equipment, decides when the runs are stopped, the regenerations started, and the intermediate subsurface washes applied. It is felt that an adequate knowledge of test results together with some judgment is required to determine when these actions should be taken. However, the automatic action of the equipment has proved to be quite beneficial in assuring that each step in the cycle is executed in the same manner each time it is done. Thus, many human errors are avoided.

A second session under the heading of water technology explored certain of the operating and experimental experiences with hydrazine. **Robert T. Hess,** chemist, and **Warren A. Greten,** engineer, The Connecticut Light and Power Co., in their paper, "Recent Application Results of the Hydrazine-Sodium Sulfite Combination," pointed out that their company is using both hydrazine and sodium sulfite as oxygen scavengers in high pressure boilers, ranging in pressure from 900 to 1800 psi. As early as 1949 the authors' company knew it had an oxygen problem culminating in a number of screen tube failures stretching over several years.

Morpholine treatment was begun on these boilers early in 1954, and a special testing program initiated to determine its effectiveness. Iron and copper content of the feedwater definitely decreased as the pH increased. However, the pH of the condensate could not be maintained about 8.6. In the attempt to reach 8.8 to 9.0 pH in the steam-condensate system, morpholine feeds were as much as quadrupled with little effect. Sulfite residuals had already been reduced to 1 to 5 ppm, which was considered the absolute minimum. Since morpholine was considered stable at this steam temperature and sulfite had been reported to decompose at this boiler pressure, it was assumed that the inability to further elevate the pH with morpholine was due to sulfite.

A 1500 psi boiler, Montville Unit No. 5, was due to startup in June of 1954, and an 1800 psi unit was on the drawing board. Both had superheat attemperation, ruling out sulfite feed to the vulnerable low pressure feedwater cycle. Therefore, provisions were made to feed hydrazine at the hot well pump discharge and as a measure of its effectiveness and as a means of control, sulfite would be fed to the drum simultaneously. With this method of treatment, it was expected that one oxygen scavenger might compensate for the shortcomings of the other.

The startup and initial operation of this unit has been reported. All indications prove this method of treatment to be a success: a feed of 0.015 ppm hydrazine pacifies the 0.008 ppm average oxygen at the hot well pump discharge. Approximately 1 oz of sulfite per day is fed to the drum to maintain a residual of 1 to 5 ppm, indicating sufficient hydrazine feed.

M. D. Baker, chief chemist, West Penn Power Co., followed with his paper, "Three Years Experience with Hydrazine." Hydrazine was first used as an oxygen scavenger by West Penn Power Co. three years ago in one 1350-psi drum pressure boiler. Since then it has been used in three more boilers of the same pressure. These four boilers initially used sulfite as a scavenger. In addition to the above, one 1500-psi drum pressure boiler has been replaced in service and this boiler had hydrazine treatment as the initial oxygen scavenger. The results to date have been very encouraging and the conditions maintained are more satisfactory than they were when using sulfite, but hydrazine cannot be considered the final solution. An oxygen scavenger that is volatile, that produces an alkaline end product, and readily reacts with the dissolved oxygen in the water is needed.

In the hunt for an oxygen scavenger that would not produce an acid condensate, hydrazine was used. This compound has been successful in eliminating acid formation. It does a fair job as an oxygen scavenger but is not entirely satisfactory. Hydrazine does not readily react with oxygen. It is possible to have hydrazine and oxygen present in the water at the same time. Hydrazine breaks down at higher temperatures to form ammonia and nitrogen. Because of this breakdown it is possible to maintain a large excess of hydrazine in the boiler water. The low residual that it is possible to maintain is a matter of concern at times. Neither sulfite nor hydrazine has proven entirely satisfactory. The need for a satisfactory scavenger is recognized so the search must continue.

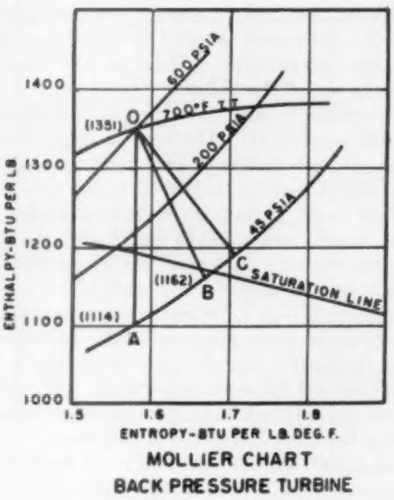
The slow reaction of hydrazine with oxygen has been described by **Leicester** and **Straub.** The inspection of boilers and feedwater systems in the West Penn Power Co. using hydrazine as an oxygen scavenger indicates confirmation of the findings given in the papers of Leicester and Straub. Mr. Baker supplied considerable detail on individual boiler experiences.

The third water technology session reported rather briefly on demineralizers and deionizers.

J. H. Duff and **Robert Dvorin,** Graver Water Conditioning Co., described "Anion Exchange Subfill as a Factor in Demineralizer Rinse Requirements." As the authors mentioned, the greatest number of demineralizers in service today are multi-bed units. Experience with this type equipment shows that where high quality water is desired a large volume of rinse water must be used to produce low effluent conductivity levels. This paper concerned itself with the effects of subfill media on the rinse requirements of anion units where strongly basic anion exchange resins are used.

Anthracite has been in use as a subfill media through the entire history of the demineralizing process. This long history of satisfactory use has shown many advantages. Despite these advantages the subfill media normally used as the anion resin bed support contributes to unit rinse requirements and reduces the average overall water quality obtained. Where 10–15 micromho/cm water is acceptable the subfill media does not markedly affect the anion unit rinse requirements. In plants where only demineralized water on the order of 5 micromhos/cm specific conductance is acceptable, the elimination of the subfill will substantially reduce final anion unit rinse requirements. This, the authors believe, can be done by a change in design of the lower internals of anion units in order to provide a bed support and distribution system without the use of a graded subfill.

Specially designed anion unit lower internals must be proved in order to obtain the full benefits of eliminating the graded subfill. These may be similar in design to the lower internals used in mixed-bed demineralizers.



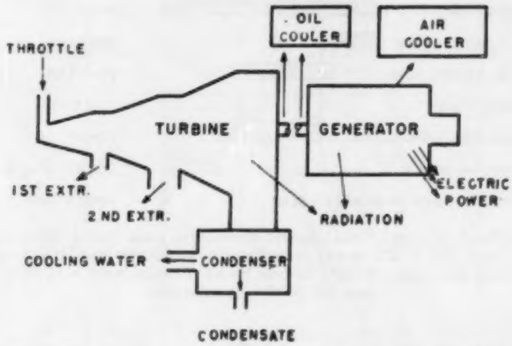


Fig. 2—Schematic view of a double extraction, condensing steam turbine shows the different changes and losses the steam experiences

← Fig. 1.—Section of Mollier Diagram portrays expansion of steam in a simple back-pressure turbine and serves as backbone for method of determining heat charges.

Allocating Heat Energy in An Industrial Plant*

Various rules of thumb have been applied when it comes to allocating heat energy in a typical industrial plant. Here is a relatively simple method held to be accurate for the proper allocation of the heat energy charges.

By RONALD J. MARTIN†

Beaunit Mills, Inc.

IN an industrial plant, an accurate allocation of heat energy between electric power generation and process uses and the apportionment of process heat energy between departments within a manufacturing plant is necessary, not only for internal cost purposes, but also to assist management in deciding between self generation and the purchase of electric power. The power engineer is usually called upon to furnish the proper figures to the cost accountants. The absolute accuracy of the distribution of energies as between departments is usually not too important. In industries where the cost of steam is between 2 and 5 per cent of the total manufacturing costs, accuracy within 10 per cent will not affect cost figures materially and is tolerable. Of course closer determinations are desirable.

However the quantity of heat charged to power generation affects the cost of power directly. The establishment of a method to compute this figure accurately with a minimum of metering equipment, is the purpose of this paper.

Allocating Heat By Btu's

There are many "schools of thought" on this subject. There are some who claim that a steam turbine should be charged with the cost of all steam which passes through it, and that the exhaust and/or extracted steam should go to process "for-free;" there are others who maintain that a steam turbine should be charged with the heat required for "straight-condensing" operation in which instance process is charged with only a portion of the heat it actually consumes; still others contend that a steam turbine is solely a reducing valve and that no steam should be charged to power generation except that which is actually condensed.

Obviously, these are extreme cases; most plants today allocate heat on a Btu basis. It is true that in order to utilize steam at a lower pressure, some departments require higher investment for larger heat exchangers, larger pipe sizes, and so on. In studying the economics of power generation, these facts should be considered; the additional cost for process equipment should be totaled with the increment cost for equipment needed to generate power and any savings should be weighed against this total investment. This paper deals with the allocation of heat on a Btu basis. In all instances heat is measured as contained in the steam from the boilers, because steam costs are usually computed as net costs from the boiler plant and charged as such.

Theory

Let us first consider what happens to the properties of the steam as it passes through a steam turbine. Fig. 1 is a section of a Mollier diagram showing the expansion of steam in a simple back-pressure turbine. Initial steam conditions are 600 psia and 700 F total temperature

* Presented before the ASME Spring Meeting, Birmingham, Ala., April 8–10, 1957 under the title "A Practical Approach to the Allocation of Heat in an Industrial Plant."

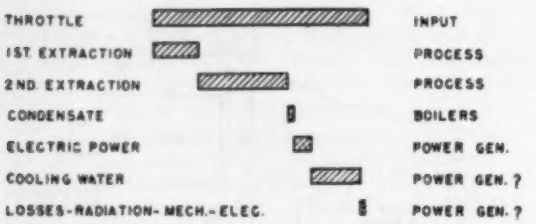


Fig. 3—A typical breakdown of steam uses for a 5000 kw, 600 psia, 700 F TT turbine indicates 40,000 lb per hr extraction at 200 psia, 80,000 lb per hr at 45 psia and a 60,000 lb per hr to the condenser

(TT). Enthalpy of the throttle steam is 1351 Btu per lb. In a perfect engine steam will expand adiabatically to the exhaust pressure of 45 psia. On the chart this is vertically downward at constant entropy (line OA). Enthalpy of the exhaust is 1114 Btu per lb. This is called the Rankine cycle. In other words the steam gives up the maximum possible energy to be converted into mechanical power. In this instance the steam gives up 1351 minus 1114 or 237 Btu/lb. Our perfect engine is frictionless and loss free. 3413 Btu is the thermal equivalent of 1 kwhr. The theoretical steam rate (TSR) of our engine will be 237 divided into 3413 or 14.4 lb of steam per kwhr.

A steam turbine is not frictionless and there are other losses. Furthermore the steam does not give up all heat possible, but because of friction and turbulence during expansion, heat and temperature changes take place and the steam actually expands along the line OB or OC, with increase in entropy. Less than the ideal or maximum possible heat is converted to mechanical energy.

The ratio of the actual heat drop to the theoretical heat drop is called the Rankine cycle efficiency. The Rankine cycle efficiency in industrial turbines of the size we are considering varies between 40 and 80 per cent, varying with load, size, and initial steam pressure. This will be discussed later.

Let us assume that our actual turbine requires say 3600 Btu in shaft energy to produce 1 kwhr, and that Rankine cycle efficiency is such that steam expands along line OB to 1162 Btu per lb. Heat drop is 1351 minus 1162 or 189 Btu per lb. Actual steam rate is then 189 divided into 3600 or 19.67 lb of steam per kwhr. This value is the steam rate furnished by turbine manufacturers. It varies with the load.

Heat Accounting

The next step to investigate is what happens to the heat which enters a turbine at the throttle. Refer to Fig. 2 which is for a double extraction-condensing steam turbine and it will illustrate all possibilities.

Steam containing energy in the form of heat (enthalpy), measured in Btu per lb, enters the turbine at the throttle. It passes through the first section of the turbine where the drop in enthalpy is converted to mechanical energy. Part of the steam is extracted at the first extraction point. The balance of the steam flows through the second section of the turbine with a drop in enthalpy equivalent to the heat converted to mechanical energy. Again some of the steam is extracted at the second extraction opening. The balance of the steam passes through the third section of the turbine where the drop in enthalpy is converted to mechanical energy. Finally this steam flows into the condenser where the latent heat is transferred to the condensing water and the heat of the liquid is returned to the boilers.

On the diagram the heat extracted at both bleed points is chargeable to process. The heat in the condensate is chargeable to the boilers. The radiation losses, the friction losses picked up in the oil cooler, the electrical and windage losses picked up in the air cooler and the energy as electric power (3413 Btu/kwhr) is chargeable to power generation. Likewise where the heat rejected in the condenser is wasted, this energy is chargeable to power generation. In some instances, pointed out later, all or a part of the heat picked up in the oil cooler, the air cooler and the main condenser may be utilized for process and is not charged to power generation.

Fig. 3 shows in block form the relative values of the heat energy for a particular set of conditions. This diagram is for a 5000-kw 600 psia 700 F TT turbogenerator, extracting about 40,000 lb per hr at 200 psia, extracting about 80,000 lb per hr at 45 psia and with a flow of 60,000 lb per hr to the condenser.

The top block represents the total heat flow at the throttle in Btu per kilowatt-hour. The next two blocks represent the quantity of heat extracted. This is obviously charged to process. The block representing the condensate is relatively small and is charged to the boiler plant. Next is the portion which represents the electrical energy output—chargeable to power. Below that is the latent heat rejected in the condenser and in some instances is charged to power generation. Finally is a small block representing the total losses, mechanical, electrical and thermal (radiation), likewise chargeable to power generation in most instances. This is a typical chart and depicts the relative magnitude of the components shown in Fig. 2 for a specific set of conditions.

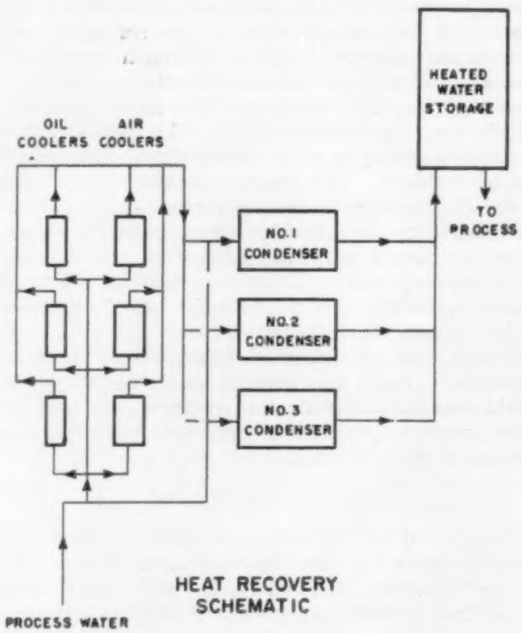


Fig. 4—Heat from the oil coolers and air coolers as well as condensers can be put to use in a process plant

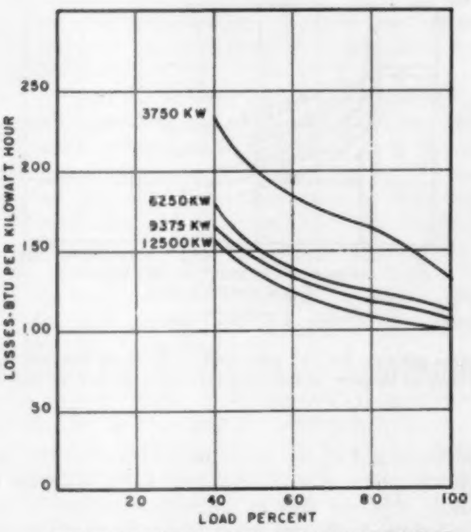


Fig. 5—Radiation, friction, windage, excitation and stator losses are combined in one loss curve for each of four different sized turbine generators from 3750 kw to 12,500 kw

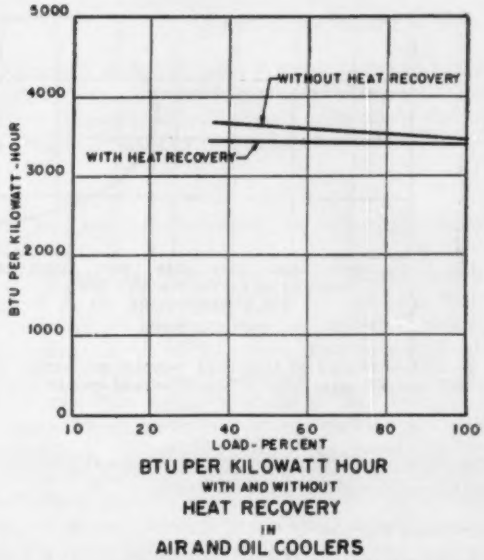


Fig. 6—Adding the losses of Fig. 5 to the 3413 Btu theoretically required for a kwhr two loss curves can be drawn—one for a unit employing heat recovery, a second for one without.

Heat Recovery

The question of heat recovery plays an important role in correctly allocating heat changes. A large number of industrial plants today utilize the main condensers to preheat process water, at least a part of the year. This is nothing new. Fewer plants, however, recover the heat from the oil coolers and air coolers. It is possible to recover most of these losses. In a plant with 15,000-kw load annual savings in excess of $3600 per year are possible.

Fig. 4 illustrates diagrammatically how this is accomplished. Process water from the treatment plant passes through the condensers to storage tanks which supply all hot-water requirements. Part of the process water is passed through all of the oil coolers and air coolers in parallel, is collected in one common header, and put through one of the condensers to storage. Radiation losses are no problem unless the storage tanks are located out of doors and then the trouble occurs only in cold weather. Our storage tanks are located high in the boiler room where the ambient temperature is equal to or above the water temperature and consequently radiation losses are no concern.

Heat Charged To Power Generation

From the foregoing discussion it is seen that the heat charged to power generation is made up of the following components: (1) Radiation losses, (2) Friction losses, (3) Electrical and windage losses, (4) Electrical energy produced (3413 Btu/Kwhr), and (5) Heat rejected in the condenser.

Item 1—the radiation losses are very small in a well-insulated turbine. The magnitude is within the accuracy of the other components and may be neglected.

Items 2, 3, and 4 represent the actual shaft power that is converted from heat energy to mechanical energy in the turbine. In other words it is the actual loss in enthalpy of the steam in passing through the turbine.

Item 5 is the latent heat of the steam which is transferred to the cooling water in the condenser.

Assuming that there is no recovery of heat in the air cooler, oil cooler, and the main condenser, then we arrive at the following formula for heat chargeable to power generation:

$$\text{Btu for power generation} = \text{kwhrs} \times K_1 + \text{condenser flow, in lbs,} \times K_2$$

It is only necessary to determine K_1 and K_2.

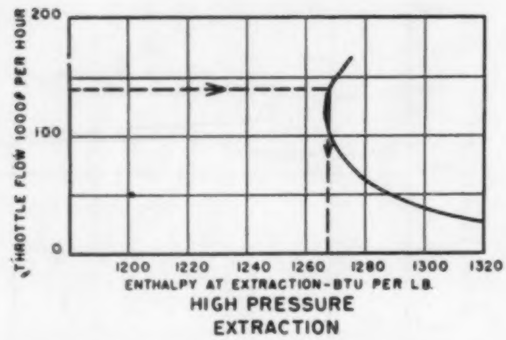
Kwhr Factor

One Kwhr is equivalent to 3413 Btu. The losses (radiation, friction and windage, electrical) may be obtained from turbine designers and for the particular machine. The sum of these two values is the factor K_1. It is the heat which is converted to mechanical energy in the turbine.

Refer to Fig. 5. This chart shows typical total losses (in Btu per kwhr) plotted against per cent load. Radiation, friction, and windage losses are about constant for all loads; excitation losses vary slightly with the load and stator losses vary pretty much as the square of the load. Hence the curves take on their peculiar shape. These curves are for data furnished by a manufacturer for turbines ranging from 3750 to 12,500 kw. As will be noted the losses are higher in the smaller machines.

If the losses are added to 3413 we obtain the Btu required to generate 1 kwhr. The curve (Fig. 6) is a plot of Btu per kwhr versus load. For all practical purposes this may be considered a straight line and ranges from 3700 Btu per kwhr at 40 per cent load to 3500 Btu per kwhr at full load. Where there is no heat recovery in the air and oil coolers, this is the factor K_1.

It is possible to recover practically all of the losses in the air and oil coolers. Under these conditions (heat recovery) the factor varies from 3460 Btu per kwhr at 40 per cent load to 3443 Btu per kwhr at full load.



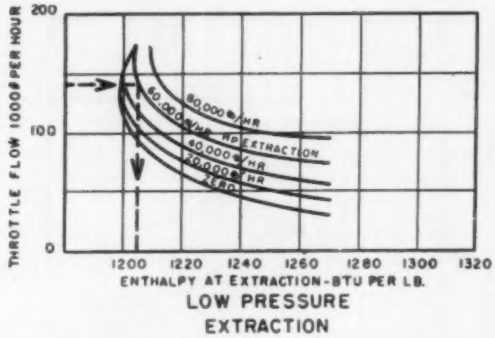


Fig. 7—The enthalpy of steam at various extraction flows for a 5000 kw, 600 psia, 700 F TT turbine is shown in the high pressure section for 165 psia and in the low section for extraction at 65 psia which the author uses for an example

Under these conditions and for all practical purposes K_1 may be considered 3450 for all loads.

Condenser Factor

The determination of the condenser factor (K_2) is not too difficult. The turbine designer can be of material assistance.

Fig. 7 is a typical curve showing the enthalpy of the steam at the extraction points of a double-extraction turbine versus steam flow in the several sections. This information may be obtained from the turbine manufacturer. This particular curve is for a 5000-kw 600-psia 700 F TT turbine with extraction at 165 psia and 65 psia.

For example, with a throttle flow of 150,000 lb per hr the enthalpy at the first bleed point is 1266 Btu per lb of steam. Rankine cycle efficiency in this section is about 70 per cent.

With a throttle flow of 150,000 lb per hr and 40,000 lb per hr extracted at 165 psia, the enthalpy at the second extraction point is 1200 Btu per lb—a Rankine cycle efficiency of 80 per cent in the second section.

For lighter loads and lower steam flows the Rankine cycle efficiency is lower—60 per cent at 40 per cent load.

In general the Rankine cycle efficiency is lower at higher initial pressures and in smaller machines; conversely it is higher for lower initial pressures and for larger machines. Fig. 8 shows the general trend of the Rankine cycle efficiency at pressures 600 psia and 200 psia and for turbines ranging from 3000 kw to 12,000 kw. Thus it may be concluded that the Rankine Cycle efficiency is higher in the lower pressure stages of an extraction turbine and that we may expect optimum efficiencies of about 80 per cent in the last section of a turbine.

Let us pursue this and determine the condenser factor for our machine.

Fig. 9 is a Mollier chart showing the expansion of the steam in the various stages of a turbine. Using the

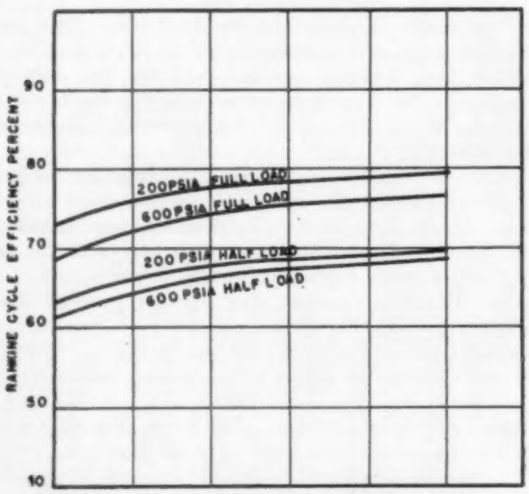


Fig. 8—Rankine cycle efficiencies run higher in the lower pressure stages of an extraction turbine to produce about 80 per cent as an optimum in the last section

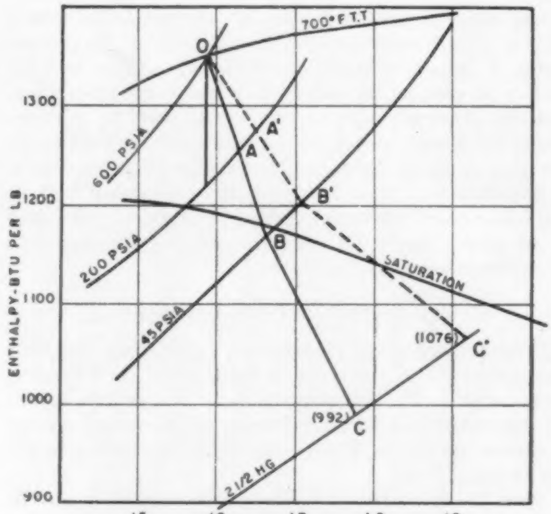


Fig. 9—Mollier Diagram above indicates the expansion of steam through the various stages of a turbine. Lines A-A′, B-B′, C-C′ mark the different stages in the example

manufacturer's chart (Fig. 7) or the curve (Fig. 8) we may determine the Rankine efficiencies in the several stages and plot the expansion of the steam for several conditions of load.

For full load the steam expands along line OA in the first section (Rankine cycle efficiency 70 per cent); in the second section the steam expands along line AB (Rankine cycle efficiency 80 per cent). Assuming an efficiency of 80 per cent from the second extraction point to the condenser, expansion will be along line BC to $2^1/_2$ in. absolute. Enthalpy at this point is 992 Btu per lb. The heat of the liquid at $2^1/_2$ in. absolute is 76 Btu per lb. Therefore our condenser factor (K_2) for this condition is 992 minus 76 or 916 Btu per lb. This is the latent heat rejected to the cooling water.

For a light load (say 40 per cent) the expansion will follow the dotted line OA′, A′B′ and B′C′ to an enthalpy of 1076 Btu per lb entering the condenser. Heat of the liquid is again 76 Btu per lb. The condenser factor for this condition is 1076 minus 76 or 1000 Btu per lb. This again is the latent heat rejected to the cooling water.

Usually the condenser factor K_2 will fall between the limits of 910 Btu/lb and 1000 Btu/lb, varying with load. Knowing the general load conditions this figure may be determined within the limits of accuracy of the meters used.

Computations

The heat chargeable to power generation in an industrial plant may be determined from two readings, the kwhrs generated, and the steam flow to the condensers.

K_1 can be called the kwhr factor. Without heat recovery from the oil and air coolers K_1 varies from 3700 Btu per kilowatthour at light load to about 3500 Btu per kilowatthour at full load. With heat recovery from the coolers a figure of 3450 may be used.

K_2, the so-called condenser factor, varies from 910 Btu per lb of condensate at full load to about 1000 Btu at real light load. An average figure of 950 Btu/lb is probably within the accuracy required. But knowing the specific conditions of load and extraction, this factor may be determined more accurately.

Then apply the formula.

$$\text{Btu for power generation} = \text{kwhrs} \times K_1 + \text{condensate wasted in lbs.} \times K_2$$

In a plant with only back-pressure turbines and where all exhaust steam is used for process, and in a plant where all heat is recovered in the main condensers, the second term of the formula can be dropped.

Conclusions

To sum up this discussion the following conclusions hold:

1 Provided that the initial steam pressure is selected to allow proper utilization of process heat, the heat consumption of an industrial steam turbine is otherwise independent of the initial steam conditions and exhaust pressure.

2 Under the same conditions, the Rankine cycle efficiency of an industrial steam turbine is relatively unimportant. Where the ratio of process-steam requirements to electric power demand is high, low Rankine cycle of efficiency may, in some instances, be an advantage. Elimination of moisture from the process steam and from the last stages of a turbine will reduce erosion and lower maintenance.

3 It is only necessary to know the kwhrs generated and the flow to the condenser, in lbs, to determine the heat chargeable to power generation. From these figures, and knowing the conditions in the plant, apply the following formula:

$$\text{Btu} = PK_1 + WK_2$$

where

P = kwhr generated
W = flow to condenser in lb when heat is wasted
K_1 = (with recovery of heat for process from the oil cooler and air cooler) = 3450 Btu/kwhr
K_1 = (without heat recovery) = 3700 at light loads
3500 at full load
Average figure of 3600 may be used
K_2 = (This factor is used only when heat in the condenser is wasted) = 1000 at light loads
910 at full load
Average figure of 950 may be used

Los Alamos Research Machine Damaged During Experiment

A critical assembly, known as the "Godiva," in operation at the Los Alamos Scientific Laboratory since August, 1951, was severely damaged during an experiment on February 12, 1957 according to a release from the AEC on March 15, 1957.

Since the experiment was remotely controlled, personnel were not exposed to radiation. No physical damage was done to the building in which the experiment was being conducted and radiation contamination of the building has been removed by standard clean-up methods with no appreciable loss of uranium. Damage to the assembly was such that it is impractical to repair it.

The "Godiva" was one of several simple critical assemblies in use at Los Alamos, for the purpose of developing information on fast-neutron systems and serving as a source of large quantities of neutrons for instantaneous irradiations, called "prompt bursts." It consisted of an unshielded spherical mass of uranium 235 about 6 and $^3/_4$ inches in diameter. The sphere was made up of three sections assembled remotely to produce chain reactions.

At the time of the accident the assembly was being used as a source of neutrons for the instantaneous irradiation of uranium-loaded graphite. The purpose of the experiment was to determine the behavior of this material after exposure to a sudden wave of neutrons.

The thermal shock which resulted in the damage was caused by a nuclear power surge considerably higher than the expected power level. One of the characteristics of the assembly was that its power operating levels were self-limiting in that the thermal expansion of the assembly resulting from power surges would cause the chain reaction to stop. In the February 12 experiment the power surged to such a level that the thermal expansion exceeded the strength of the uranium metal.

A Survey of Operating Hot Lime-Zeolite Plants*

By L. F. WIRTH, JR.†

National Aluminate Corp.

Numerous large and small plants employ hot lime-zeolite for softening boiler water makeup. Here is a report on certain of the operating problems experienced by these plants and some comments on the generally successful results attained

THE hot lime-zeolite system was first reported as a method of preparing boiler feedwater for medium to high pressure boilers at the 1950 Annual Meeting of ASME (1).[1] Several hundred plants of this kind have since been placed into operation. These range in size from smaller than 100 gpm to as large as 8000 gpm and are operated at temperatures from 210 F to 290 F. Boilers using the water range in pressure from 150 psi to 1350 psi. Acceptance of the process is greatly attributed to the already established confidence in the hot process softener and the reliability of the zeolite softener as a method of producing low hardness water. With the development of the styrene type cation exchange resin, high temperature zeolite operation became possible so the two processes were merged into a highly reliable system which is now being operated to suit widely varying conditions of raw water supply and feedwater requirements. Among the systems operating are several converted hot lime-soda plants, some converted hot lime-soda-phosphate systems and many plants built as lime-zeolite systems.

The original hot process softener used lime and soda ash as treating chemicals. Coagulants such as sodium aluminate greatly improved operations. Soda ash was quickly dropped as a treating chemical when the zeolite softener was added. The system then became known as the hot lime-zeolite softener. Lately, soda-ash has been reinstated and used in sufficient quantity to reduce total hardness of the hot process softener effluent to 85–100 ppm when treating waters high in non-carbonate hardness. Better magnesium and silica reduction has resulted. No excess soda is maintained.

Many early installations utilized common backwash systems for the filters and zeolites. Refinements of design have since made possible the production of feedwater extremely low in hardness. Resin life has been as good as, or better than, predicted in most instances. However, there have been a few problems with resin deterioration. Those that have come to our attention have been corrected and a few will be discussed later.

This paper reports on the operating conditions found at several plants and includes some information on the boilers using this source of makeup. A breakdown of the industries surveyed in this study, plant sizes, operating results and boiler conditions, is contained in Table I. This summary indicates a general preference for the process to supply makeup water to large boilers operating at pressures of 400–900 psi. Paper mills are among the greatest number of user industries. Process industries such as chemical, oil and others using steam rank next in number. This order is not necessarily true for the industry at large, but it does reflect the conditions relating to this survey. Boiler conditions correlate well with softener operating conditions. Both softener and boiler operations are good in a high percentage of cases studied. Fair to poor boiler conditions are generally found when fair to poor softener operations are observed. Fifty-four plants were studied by a general questionnaire to our field districts servicing these plants. Additional study of numerous service call reports as well as a collection of correspondence pertaining to plant operation have brought out the importance of adequate equipment design and some operation procedures worthy of note.

TABLE I—BREAKDOWN OF PLANTS AND INDUSTRIES SUPPLYING DATA

HOT LIME-ZEOLITE UNITS	SIZE-GPM
20	< 200
28	200-1000
4	1000-2000
2	>2000

HOT LIME-ZEOLITE UNITS	SUPPLYING WATER TO BOILERS-PSIG
10	< 250
9	250-400
32	400-900
3	900-1350

HOT LIME-ZEOLITE UNITS	OPERATING CONDITIONS REPORTED-SOFTNERS
39	Good
10	Fair
5	Poor

HOT LIME-ZEOLITE UNITS	INTERNAL CONDITIONS REPORTED-BOILERS
42	Good
10	Fair
2	Poor

HOT LIME-ZEOLITE UNITS	INDUSTRIES INCLUDED IN SURVEY
20	Paper Mills
9	Oil Refineries
2	Steel Mills
11	Chemical Plants
7	Power Utilities
5	Other

* Presented before the American Power Conference, Sponsored by Illinois Institute of Technology, Chicago, Illinois, March 27–29, 1957.

† Manager, Ion Exchange Division.

[1] Numbers in parentheses refer to list of References at end of the article.

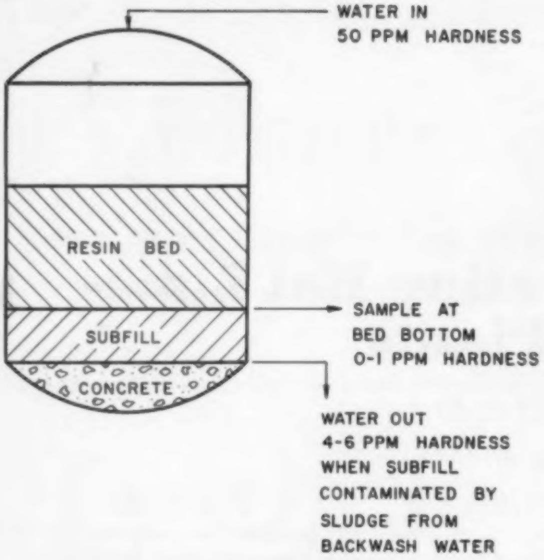


Fig. 1—Sludge in sub-fill is dissolved by soft water leaving resin bed. Such sludge causes high hardness and longer rinse than with clean sub-fill

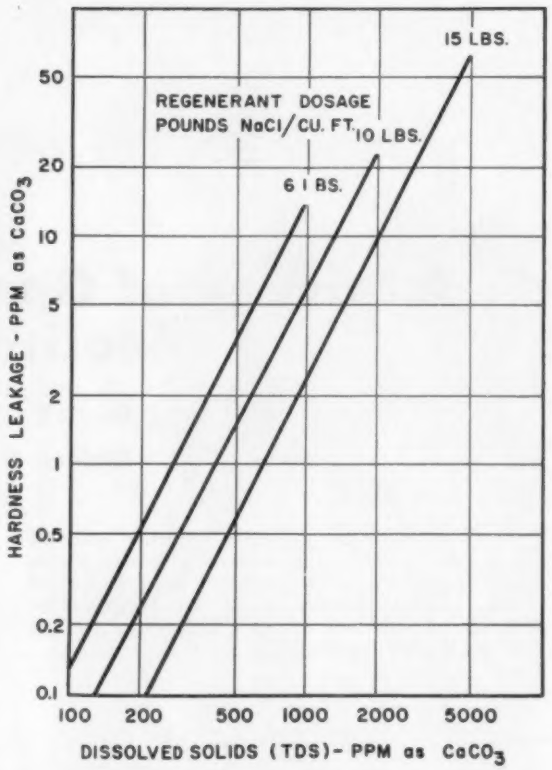


Fig. 2—Hardness leakage values greater than shown would indicate faulty regeneration or the presence of sludge in sub-fill, or both, chart, right

Hardness Leakage

To produce the low hardness water possible from a hot lime-zeolite system a supply of clear, low turbidity backwash water is necessary. Filtered water or zeolite softened water are the best sources of backwash supply. Water from a storage tank, unless it is thoroughly settled, should be considered a second choice to filtered water. A storage tank used for handling both filter and zeolite wash water will seldom be free of suspended matter and small amounts of sludge from the filters can easily contaminate the zeolite units. Sludges from the primary system usually consist of calcium carbonate and magnesium hydroxide and some silica. If any suspended matter enters the zeolite sub-fill during backwash, some will remain after regeneration. A prolonged rinse following regeneration or backwash will then be required to produce water quality suitable for high pressure boiler use.

Magnesium deposits have been found in some boilers and it has been suspected that the zeolite units have failed to remove magnesium completely. Very early studies of the process indicated that at hardness breakthrough of the zeolite unit, calcium was predominant with very little magnesium present. This would be expected, since in a well operated system magnesium is reduced to a few ppm in the primary softener, while calcium may be present in quantity of 100 ppm or more. In our opinion, magnesium found in boilers has for the most part originated as sludge which carries through with the wash water and collects in the sub-fill of the zeolite softeners. The only source of magnesium in quantities sometimes observed in the zeolite softener effluent would, therefore, have to come from turbidity carried into the zeolite units through the filters or with the backwash water. This point cannot be emphasized too strongly.

Magnesium hydroxide is light and flocculent and is often an appreciable constituent of turbidity leaving a hot process softener. In studying problems of this kind the wash water to the zeolite softener should be sampled at one minute intervals during a normal backwash to see if the supply remains clear during the entire backwash period. Prolonged backwashing of a hot zeolite softener may cause trouble, since this requires larger volumes of water than calculated for a normal wash period and if this quantity is exceeded, turbid wash water may result. To illustrate how hardness may enter the finished supply by contamination of the sub-fill, we have made a section drawing of a water softener in Fig. 1 along with examples of hardness content of water at various points. Dissolving of suspended matter in the sub-fill causes the increase in hardness shown.

Fig. 2 shows the hardness leakage values expected of high capacity resin for waters of various dissolved solids content and when using different salt dosages (2). The amount of salt required to produce water of high quality will vary with the water supply. If hardness leakage is higher than shown in this plot, contamination of the sub-fill or valve leakage may be the cause. Versenate tests are affected by iron, so care must be taken in sampling to assure a representative sample. Small diameter sample lines of copper, stainless steel or Monel which will purge themselves rapidly and minimize sample "lag" should be used.

The importance of low turbidity backwash water can

be illustrated by a study of plant A. Long rinses causes heavy rinse water loss and prolonged outage time. Resin beds were suspected to be fouled and acidizing of the units was being considered. By careful analysis of the influent and effluent water during an operating cycle, the cause of difficulty was detected. The water entering and leaving the zeolite units had essentially the same alkalinity of 30 ppm at the time of testing. The alkalinity of the zeolite effluent was only 4 ppm higher immediately after regeneration and this was reduced to no difference as the run progressed. Since calcium carbonate sludge is soluble in zero hardness water, it is unlikely that fouling of a zeolite bed in a hot lime-zeolite system can exist without causing an appreciable increase in the alkalinity of the softened water. We have actually recorded increases in alkalinity as large as 15–20 ppm leaving the zeolite softener due to dissolving of sludge deposited in the zeolite bed. This solubilized calcium carbonate immediately converts to sodium carbonate in the resin bed. This conversion expends exchange capacity which must be added to the original hardness content of the water in order to correctly evaluate unit exchange capacity.

The long rinse experienced at plant A was not caused by a dirty resin bed, but by suspended matter that was deposited in the sub-fill during backwash. At this particular plant a backwash storage tank was used for both filter and zeolite wash water. The tank was adequately sized to handle either condition and with ample settling time to assure a reasonably low turbidity water for backwash purposes. The hardness leakage following regeneration was higher than desired and long rinses were required to produce good quality water. To correct this condition the operators attempted to clean the resin beds by backwashing for longer periods. This added volume of water exceeded the usable capacity of the backwash storage tank and the dirty water was recirculated back into the zeolite unit contaminating both the bed and subfill. The rinse problem thus became acute and was temporarily corrected by reducing both filter and zeolite unit backwash time to a minimum. Since this plant has adequate filter capacity, filtered water is now being used for the zeolite backwash. The backwash water tank now supplies wash water for filters only. Fig. 3 illustrates how dirty backwash water can affect water quality from a hot zeolite softener.

Resin Life

With few exceptions resin life in hot zeolite service has been good. Difficulties with chemical breakdown have been encountered in a few instances and the ultimate solution to these problems has been quite simple. As mentioned earlier, plants are operating at temperatures as high as 290 F. Numerous samples of resin have been evaluated and in some cases deterioration has been severe, requiring bed replacement in less than a year. Temperature of operation has not been important as far as it affects resin. In fact, the higher temperature plants have, with one exception, enjoyed the best resin life. A few case histories bring out some interesting points.

At plant B the operating temperature was 290 F. Since studies in the laboratory showed resin stability at least up to 350 F, it was reasonable to expect as much as 3 years life from the resin. After 10 months' operation the beds collapsed and had to be replaced. Samples taken after 6 months of operation showed the capacity to be down about 15 per cent in column operation, but the exact reason for this could not be determined at the time. Additional study revealed that the structure of the resin had broken down causing the particles to swell which was accompanied by an increase of the water content. Water content measurement is in our opinion the most important test in evaluating the chemical condition of stryrene high capacity resins. A water content study of resin at plant B is shown in Fig. 4. Note that after a new bed of resin was installed, the temperature was reduced to 230 F, but this only slowed down the deterioration.

Further study at the plant showed that residual chlorine was present in the hot zeolite influent water and this was entirely absent in the hot zeolite effluent. The chlorine was present in the raw water to an extent of 2.5 ppm and a slight residual was usually prevalent after passing through the hot process softener. The feeding of sodium sulfite for removal of chlorine completely stopped the rapid deterioration as indicated on the curve showing condition of the second bed of resin installed and also the third bed placed into two of the units. The damaged resin was all ultimately replaced and operation has continued successfully for several years with sodium sulfite feed.

At plant C deterioration similar to B was experienced, but in this case the temperature was only 230 F. Dis-

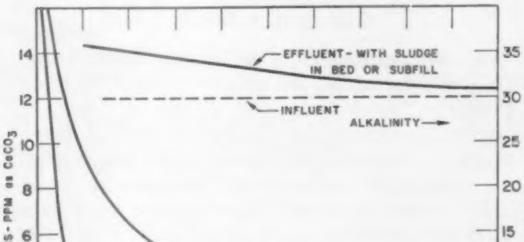


Fig. 3—Turbid backwash water causes increased alkalinity and hardness leakage when used on hot zeolite softeners

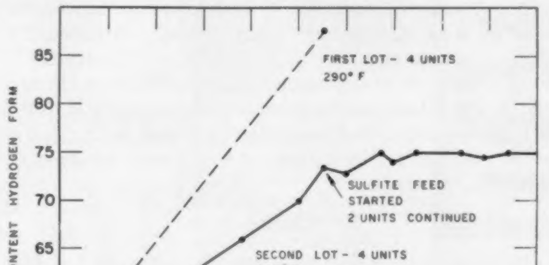


Fig. 4—The first and second beds of resin were damaged by chlorine residual in the hot filtered water. Sodium sulfite feed corrected the condition

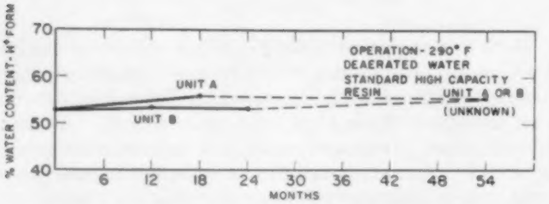


Fig. 5—Resin stability at 290 F is excellent in this hot lime-zeolite plant. The absence of oxidizing conditions is illustrated by the very small change in water content of the resin

FIGURE 6

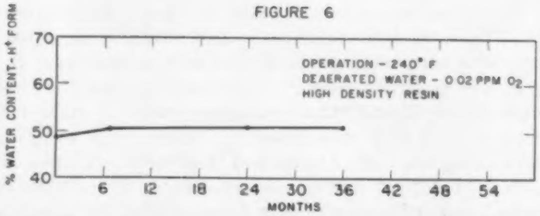


Fig. 6—This lower water content resin has higher density. Only small changes in operating properties of the resins are noticed with changes in water content until 58–60 per cent water is reached. Physical changes then cause higher pressure drop, increased expansion with backwash

solved oxygen present in an amount of 0.5 ppm was suspected to be the cause and sodium sulfite feed corrected the condition. It is possible that oxygen may have contributed to the problem at plant B, but this is not known to be the case.

At plant D dissolved oxygen is very low as the water supply lends itself to deaeration in the hot process softener. Temperature of operation is 290 F. Resin condition observed in Fig. 5 indicates that the absence of oxidizing agents assures maximum resin life and that the resin is stable under such conditions even at temperatures as high as 290 F. This information has been helpful in evaluating applications of high density styrene cation resins. In fact, it has made possible planned operation in the absence of oxidizing conditions at temperatures as high as 450 F for a few months.

Deterioration studies such as these should have some influence on future plant design. Oxygen content of the hot process water was not originally considered important with the exception that corrosion of equipment had to be kept to a minimum. Hot process softeners normally heat the water by a single stage contact with steam and, depending upon venting and other factors, oxygen usually is present in amounts of 0.1–0.5 ppm O_2. A second deaerator completes the removal of oxygen, but this is usually after the zeolite treatment is finished. To obtain maximum resin life in high temperature service there is advantage in removing oxygen in the hot process softener to less than 0.1 ppm. When this cannot be done, sodium sulfite feed will correct the condition at very low cost.

Plant E is the largest in operation. A study of resin life in Fig. 6 shows very little change in resin condition during 3 years of operation. This plant contains about 4500 cu ft of high density resin, recently introduced to the market, to provide longer life in severe service. A small change in water content occurred between the original and first samples, however, this apparently is due to swelling during initial operation of a new resin. We do not know exactly the reason for this, but it has been observed in other cases.

Summary

In summary, we feel that the utility of the hot lime-zeolite process of treating boiler feed make-up has been demonstrated. Numerous large and small plants are supplying water to both low and high pressure boilers. We do believe, however, that a true evaluation of the merits of this system of water treatment is in order. Equipment builders, engineering consultants, and potential as well as current users of the process should study the design features which influence the production of low hardness feedwater. Ample facilities should be provided to supply turbidity free backwash water. Also, the information available on conditions affecting resin life should be brought into the drawing room as this can influence the design of heating and deaerating apparatus in the primary softener. In some cases it may even be desirable to delay final softening until the primary softened, filtered water has been deaerated. This could be done quite easily with either a separate deaerator or as a component of the primary hot process softener. Even though equipment is properly designed and adequately sized, good operation is essential to insure a continual flow of low hardness feedwater.

While the suggested temperature of operation has been limited to 250 F in the past, successful operation is quite possible at temperatures in the 290–300 F range. With provision for complete removal of oxygen and chlorine we see no reason why operation cannot be carried out at these temperatures with good resin life. We do suggest that high density resins be used in hot zeolite systems, and that a reasonable schedule of resin replacement be considered as part of the operating cost of the process.

REFERENCES

(1) ASME Paper 50-A-77 "Power Plant Operation with Hot Lime-Zeolite Process," L. F. Wirth, National Aluminate Corp., and W. S. Butler, Dow Chemical Co.

(2) Nalco Bulletin No. 58 "Nalcite HCR Revised Edition."

Correction Notice

W. W. Schroedter, Combustion Engineering, Inc., who translated the article "State of Slagging Furnace Development in Germany" by P. Grasme, appearing in our February 1957 issue, pp 34–41, called our attention to an error appearing on p 39, first sentence, first paragraph.

This sentence states "Most German coals have fluid temperatures up to about 1650 F and are therefore . . ." The temperature is actually 2650 F and should so state.

Fifth Annual Conference on Atomic Energy

Last month's issue of COMBUSTION reported on the Nuclear Congress then in session in Philadelphia, March 11–15. The last two days of that Congress were given over to sessions by the Hot Laboratories and Equipment Conference and to the National Industrial Conference Board's Fifth Annual Atomic Energy in Industry Conference. The Hot Laboratory papers were descriptions of individual laboratory installations and certain specific laboratory equipment and operation.

The Industrial Conference Board selected their papers as is their custom to feature items of interest to management or to the economics of atomic energy development. A sample of these papers are abstracted below.

The General Report

Carl T. Durham, U. S. House of Representatives and Chairman, Joint Committee on Atomic Energy, at the Conference dinner session sketched the "state of the nation" in the atomic field in his talk "Some Realism on Atomic Power Development." His talk covered military, power, foreign and research reactors and touched on certain of the more outstanding problems. In summary Mr. Durham asked what do we do about it? And then he offered the following suggestions subject to further study and consideration by the Joint Committee:

1) Authorize construction of an additional plutonium producing reactor at Hanford, Wash. It would seem wise to also make provision for utilizing the waste heat for producing electric power.

2) Authorize the development and construction of a Mark I Flying Prototype of a nuclear propelled aircraft with a realistic target date for completion.

3) Substantially increase AEC funds for reactor research and development work.

4) Inaugurate an accelerated domestic reactor demonstration program which will ensure that we will have a variety of operating prototype power reactors in this country by 1961 or 1962.

5) Establish a foreign power-reactor demonstration program which will assist friendly nations abroad and help provide research and development assistance and a foreign market for domestic equipment manufacturers.

6) Enact the indemnity legislation to cover liability for reactor accidents.

Finally, Mr. Durham expressed the wish to emphasize that time is of the essence at this junction. He did not believe we need a "crash" program. But on the other hand he said we can't afford to wait too long where our national prestige and world leadership is at stake.

The Manufacturer's View

Leo Macklin, manager, Nuclear Power Sales, Combustion Engineering, appearing on one of the many panels spoke on the subject "Long-Range Outlook for the Nuclear Power Equipment Industry." He described the effect of severe standards upon equipment design not only for the new but for the conventional components which made rigorous engineering analysis a basic requirement to each job.

At this point in our development of nuclear power, we have learned, Mr. Macklin stated, that designing, developing and building power reactors and their components takes a good deal of equipment and capital. Codification, standardization and relaxation of severe requirements are prerequisites if the nuclear power equipment industry is to look forward to significant expansion. Several comments were then offered regarding this long-range outlook: (1) Research and development will undoubtedly continue to be a necessary part of the operations of a nuclear equipment manufacturer. (2) Some of the rigid manufacturing requirements must be relaxed by purchasers or production capacity will be severely limited. (3) Codes and standards must be established to eliminate the need for costly and exhaustive engineering studies. (4) Adequate insurance protection must be made available.

System Designs

Four speakers were chosen to cover the various commercial power reactors under the heading of natural vs. enriched fuels. Among the comments were those by **W. Bennet Lewis,** vice president, Research and Development Atomic Energy of Canada, Ltd. In the case of Canada, Mr. Lewis pointed out large-scale use of nuclear power is conditional upon cost being less than 6 mills per kwhr. Mr. Lewis then described certain experience with the NRX heavy reactor which, he feels, might make this system using natural uranium a better choice than enriched fuel cycles.

John B. Menke, president, Nuclear

Development Corp. of America, also spoke of the advantages of natural uranium. He felt that with gas or liquid coolants thermally insulated from the heavy water, reactors could be built that would enjoy lower costs.

Dr. Chauncey Starr, general manager, Atomics International, and vice president, North American Aviation, Inc., took the case for the enriched fuel which, he believed, carried the advantages of a wide latitude in selection of reactor types and materials of construction as well as smaller reactors for a given power output. However Dr. Starr emphasized no generalized statement can be made since the specific characteristics of any proposed installation will determine the relative advantages of each fuel.

NEW EQUIPMENT

Heat Control

Building and process steam control is said to be simplified with the advent of the new C. E. Squires Co., Cleveland, Ohio, *Valvatrol*. This device, adjustable, slow-opening yet capable of fast and positive steam flow dead-end, permits a piping system to be warmed up without operating noise and tenant discomfort.

Basically designed for accurate building and process temperature control the unit can, if desired, simultaneously reduce steam automatically from full line pressure (to 600 psig maximum) down to the precise pressures of high vacuum systems. One small control package eliminates the usual two valves for pressure reducing and motorized control.

Temperature Control

Three-position pyrometer temperature controllers now being offered by West Instrument Corp., Chicago, are reported to be easily wired for a wide variety of specialized control applications: heating with automatic cooling; motor operated fuel valve; high-low-off or high-low-medium electric or fuel systems; control with high limit feature and automatic reset.

These new West instruments are said to eliminate costly manual control and reduce spoilage of product and deterioration of equipment. They are used with plastic extruders, industrial ovens, furnaces, and provide for two types of neutral band, each with two types of control. Details are listed in Bulletin JT-1 available from the manufacturer.

Safe Acid Handling

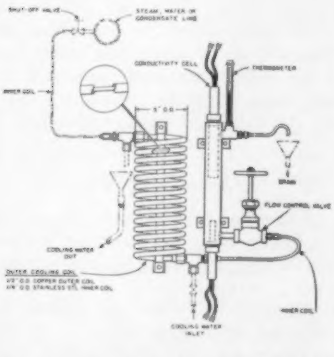
Graver Water Conditioning Co., New York, N. Y., is offering a method of acid handling which is said to render this duty safe and simple. The system can be furnished as part of the regenerant system of water treatment processes such as demineralization, hydrogen zeolite ion exchange and acid stabilization. Known as the *Graver Vacuum Acid Handling System*, it enables the transfer, measurement and dilution of acid to be accomplished without lifting carboys or drums and without subjecting any vessels to positive pressures.

Only a water line need be added to the system as furnished. The acid is drawn from the drum or carboy to the measuring tank by the vacuum created by the water operated ejector. When the proper amount of acid is in the tank, the flow is stopped by merely opening a

vacuum breaker. Excess acid draws back to supply source. After the dilution tank is filled with water, the measured acid is drained into the dilution tank. The proper amount and concentration of acid is then ready for use in the regeneration system.

Cold Drawn Seamless Tubing

Cold drawn *Inconel* and type 304 stainless steel tubing, as furnished by Superior Tube Co., Norristown, Pa., has been reported to help Parker Appliance Co. get maximum efficiency from its dual heat transfer coil for cooling liquids and gases since the *Inconel* and stainless internal sampling coils (wherein the hot liquid or gas is cooled) have uniform wall thickness and are free of defects, assuring safety with a thinner wall for efficient heat transfer. The wall uniformity also helps Parker produce coils which are concentric. This allows inner tubing to be centered inside outer tubing—permitting an even flow of water on all sides, giving an even cooling effect. See illustration of a water sampler, below.



The Parker dual heat transfer coil is made in three sizes. Outside diameters of the internal tubes are $^1/_4$, $^3/_8$ and $^1/_2$ in. with wall thicknesses of .049, .049 and .065 in. respectively. The outside diameter of the copper external tube (through which cooling water flows) is $^1/_2$, $^3/_4$ and 1 in. for the three coil sizes.

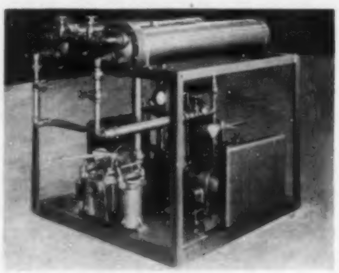
For pressures below 1000 psi and temperatures below 700 F both coils are made from copper tubing. For pressures between 1000 and 2000 psi and temperatures between 700 and 1500 F, the inner coils are either Inconel or stainless, as specified by the customer.

Heater Pump Sets

Packaged heater pump set combinations for preheating, straining and pumping heavy No. 5, No. 6 and Bunker C fuel oils are available in duplex or single assemblies with each set a completely self-contained unit, ready for immediate operation as soon as con-

nections are made to the fuel line and electrical service according to York-Shipley, Inc., York, Penna.

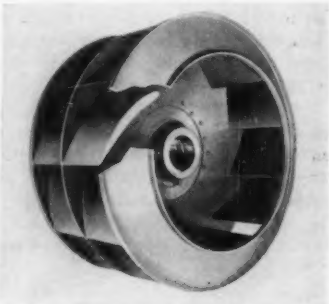
Manufactured for use with all burners designed to burn heavy oil, these pump and preheater assemblies come in four



standard sizes: Model 100, pump size 2C, 100 gph; motor 1/2 hp, Model 225, pump size 3C, 225 gph; motor 3/4 hp, Model 400, pump size 4C, 400 gph; motor 1 hp, Model 700, pump size 5C, 700 gph; motor 1 1/2 hp. Single assemblies include oil preheater, duplex oil strainer, fuel pump, motor, pushbutton magnetic starter, pressure gage reading from 0 to 160 psi, 3/4-in. relief valve, sheaves and belts, fan-type temperature gauge, check valve and gate valve. These components are assembled and mounted on a steel base plate and frame. Aquastat and circulator for hot water or steam solenoid for steam are also furnished, but not mounted.

Centrifugal Fans

A new line of *Airfoil* centrifugal fans for heavy duty industrial applications is now available from American Blower Corp., Detroit, Michigan. These new units come with single and double inlet construction in a large number of sizes for volumes up to 1,000,000 cfm. Blade design plus improved design of streamline inlets, wheel rims and housing are reported as contributing to high efficiency. The new fans feature low oper-



ating cost and operate at a mechanical efficiency of more than 92 per cent and static efficiency over 88.5 per cent.

The wheel in the new fans is of welded construction with blades of airfoil cross section, reinforced for additional strength and the hub of cast steel.

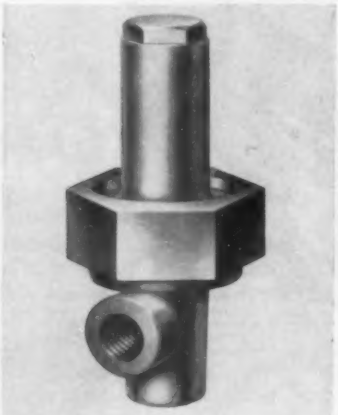
Steam Purifier

Plants desiring to reduce the cost of their power operation, the V. D. Anderson Co., Cleveland, Ohio, claim can conserve water and steam through the use of their new model LS *Hi-eF* steam purifier. Instead of exhausting spent steam to the atmosphere where it is of no value, the purifier is installed in low pressure steam lines on the exhaust

side to remove oil, pipe scale and other impurities so that the steam can be returned to the boiler. This action not only reduces the amount of raw feed water required for the boiler, but is said to actually cut the company's steam cost since condensed water is less costly to generate into steam than raw water.

Corrosion-Resistant Valves

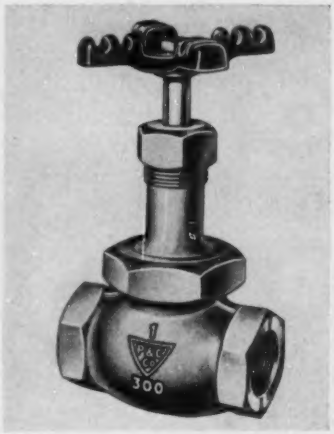
Milton Roy Co., Philadelphia, Pa., recently announced the availability of a new line of relief valves and back pressure valves which can be used with corrosive fluid at pressures to 1500 psi and temperatures to 250 F. The top works of these valves are protected by *Kel-F* thermoplastic diaphragms.



Available in standard $^1/_4$, $^1/_2$, $^3/_4$ and 1-in. sizes, these valves offer a wide range of pressure settings which are easily made with a screw driver. For high corrosion resistance, valve bodies are constructed of cast steel, 316 stainless steel, Carpenter No. 20 and Hastelloy C. Additional details and specifications are given in the company's bulletin No. 1255-B.

Bronze Globe Valve

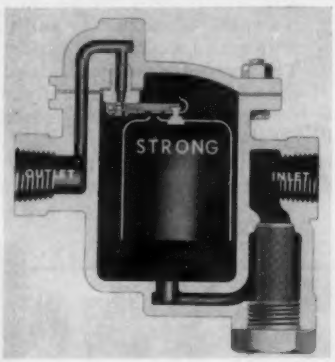
Designed for dependability, the heavy-duty construction, Fig. 427-DP bronze globe valve of R-P&C Valve Div., American Chain & Cable Co., Reading, Pa., is recommended for industrial applications of steam, water, oil and gas service where continuous control or regulation of control is required. The manufacturer claims that the device is particularly effective for frequent or continuous throttling and other severe applications.

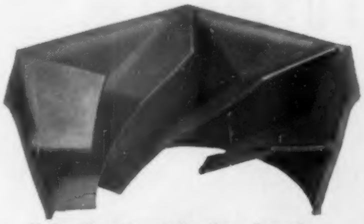


The valve's stainless steel disc and seat ring is of 500 Brinell and/or Rockwell C-52 hardness to resist wire-drawing by high velocity currents and abrasion or by gritty particles. It is rated for 300 psi steam at 550 F maximum—1000 lb OWG in $^1/_2$ to 2 in. sizes, and 600 lb OWG in the $2^1/_2$ and 3 in. sizes.

Trap with Built-in Strainer

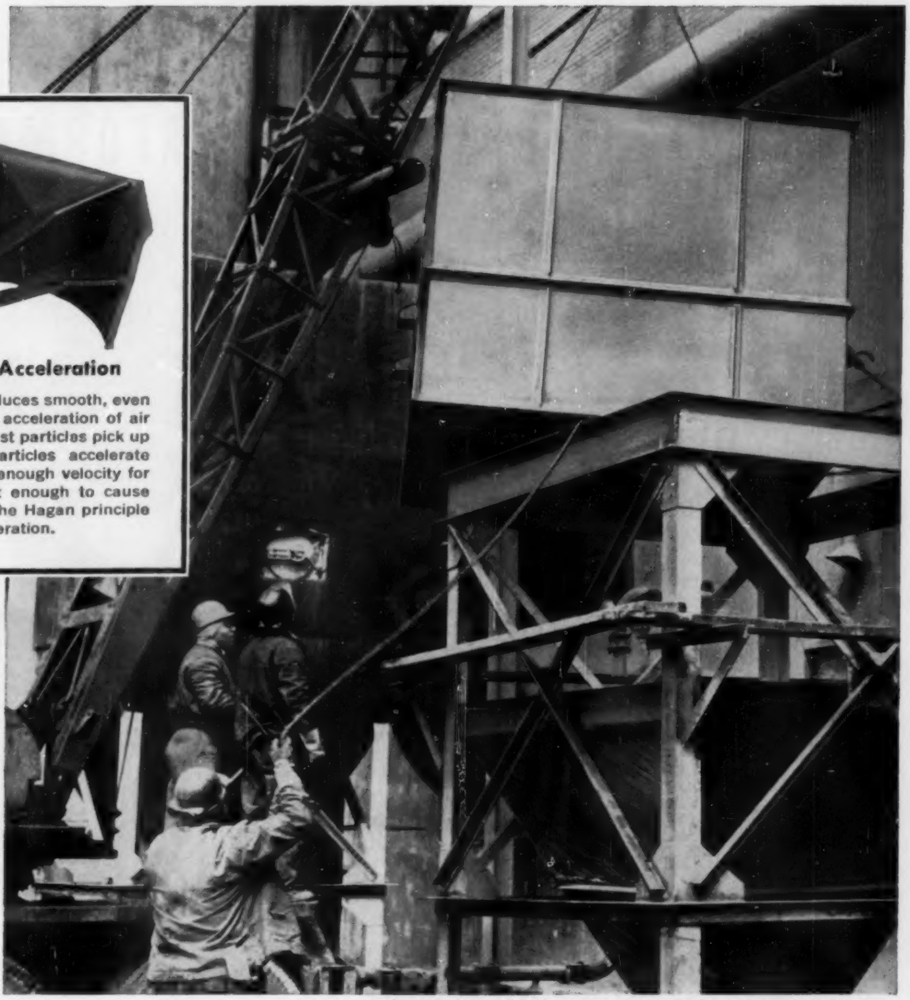
Production of the new 140-S *Hydro-Flex* steam trap has been announced by Strong Steam Specialties Div., Strong, Carlisle & Hammond, Cleveland, Ohio. A distinctive feature is the built-in stainless strainer with its screen installed in a vertical position which prevents clogging and reduces cleaning maintenance time. Other features are said to be small size and weight.





Selective Particle Acceleration

Inlet cell vane design produces smooth, even deflection and controlled acceleration of air stream. Smaller lighter dust particles pick up speed quickly, larger particles accelerate more slowly. Both attain enough velocity for good separation, but not enough to cause erosion damage. This is the Hagan principle of Selective Particle Acceleration.



Installation of fully pre-assembled Hagan Dust Collector

Minimum erosion, fast installation...

HAGAN MECHANICAL DUST COLLECTOR

Fast installation is one of the features of the new Hagan Dust Collector. Recently a collector for a 75,000 lb/hr boiler was erected in less than fourteen hours. With the duct work connected up, it was ready to go.

The Hagan vaned-nozzle inlet design has practically eliminated tube erosion and collection efficiencies are raised, because of high effectiveness in the 1 to 10 micron range. Check these cost and trouble-saving features:

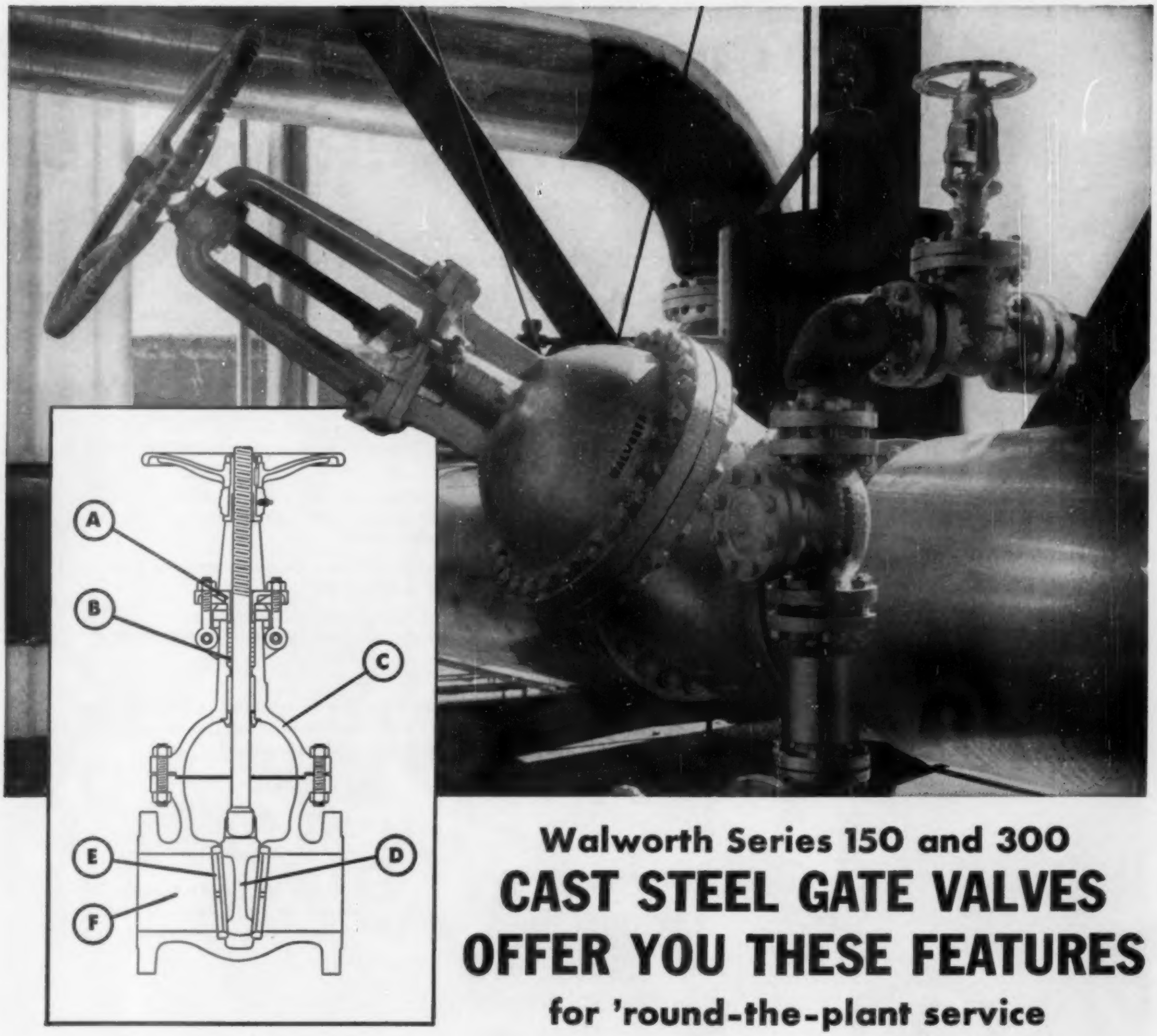
- Tube erosion virtually eliminated. Hagan Dust Collectors are *guaranteed* against tube failure due to erosion *for two full years.*
- Pressure drop 20% lower than conventional multiple tube collectors based on same efficiency.
- Hexagon shaped tops—This honeycomb shape permits close tube packing, eliminates dust trapping and clogging.
- Easy maintenance—Ease of access to all parts makes the Hagan Dust Collector easy to inspect.
- Lower overall height requirements.

Add to these the fact that the Hagan Dust Collector's efficiency easily meets the most rigid existing code requirements for coal fired boilers for any city in the United States.

Write for specifications, or a Hagan engineer will be glad to discuss your particular requirements.

HAGAN CHEMICALS & CONTROLS, INC.

HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES



Walworth Series 150 and 300

CAST STEEL GATE VALVES OFFER YOU THESE FEATURES

for 'round-the-plant service

(A) GLANDS: Clearances between the gland and stuffing box, and gland and stem, are such that the stem cannot be scored even if the gland is pulled down unevenly.

(B) DEEP STUFFING BOXES: More than adequate in all sizes (2" to 24") to assure tightness and maximum packing life.

(C) BONNETS AND BODIES: Engineered to exceed the requirements of all applicable codes and standards. They are tough, durable, dependable.

(D) INTEGRAL GUIDE RIB FACES IN BODY: Machined to insure accurate centering of the gate.

(E) STURDY SEAT RINGS: Bottom-seated so that no recess exists at the back of the ring to cause turbulence, erosion and pressure drop.

(F) STREAMLINED PORTS: Permit unobstructed flow which results in minimum pressure drop and reduces the possibility of erosion.

Walworth Cast Steel Gate Valves can be furnished with either flanged ends or butt welding ends. Roller bearing yokes are available on the larger sizes. On valves 4 inches and larger, by-passes can be furnished.

Walworth Cast Steel Gate, Globe and Check Valves from Series 150 to 2500, are available. For Series 600 and higher, we recommend Walworth Pressure Seal Cast Steel Valves. See your Walworth Distributor or write to Walworth for complete information.

WALWORTH

60 East 42nd Street, New York 17, New York

SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. CONOFLOW CORPORATION M & H VALVE & FITTINGS CO. SOUTHWEST FABRICATING & WELDING CO., INC. WALWORTH COMPANY OF CANADA, LTD.

Now you can buy a
Bailey-built HEAT PROVER Analyzer

CONTINUOUS READINGS OF OXYGEN AND COMBUSTIBLES

The famous Cities Service HEAT PROVER Analyzer, formerly available only on loan, is now manufactured by Bailey Meter Company, and you can buy one outright. With this handy portable instrument, you can easily monitor the per cent of oxygen and combustibles in gases.

The continuous readings from a Bailey HEAT PROVER Analyzer enable furnace, kiln, and engine operators to correct combustion variables before costly losses are incurred. Although it weighs a scant 25 pounds, the HEAT PROVER Analyzer is the key to maximum combustion efficiency. With it, the operator can determine the proper proportion of fuel to air at any time.

The two meters on the analyzer show per cent by volume of oxygen and combustibles on either a 20% range span or a more sensitive 4% range. Temperature of flue gases in degrees Fahrenheit is also shown.

Compared with involved, time-consuming Orsat measurements of flue gases, this new portable analyzer offers these advantages:

1. Simultaneous direct readings of oxygen and combustibles.
2. Negligible time lag between combustion change and reading change.
3. Continuous sampling, analysis, and readings.
4. Convenient measurement of temperature.

Ask your Bailey engineer how you can use this instrument to increase combustion efficiency. Or, write today for more information on how this new Bailey HEAT PROVER Analyzer can pay for itself practically at once. G-39-1

Flue gas analysis with a Bailey HEAT PROVER Analyzer at a furnace stack. Per cent oxygen and combustibles is shown continuously.

Instruments and controls for power and process

BAILEY METER COMPANY

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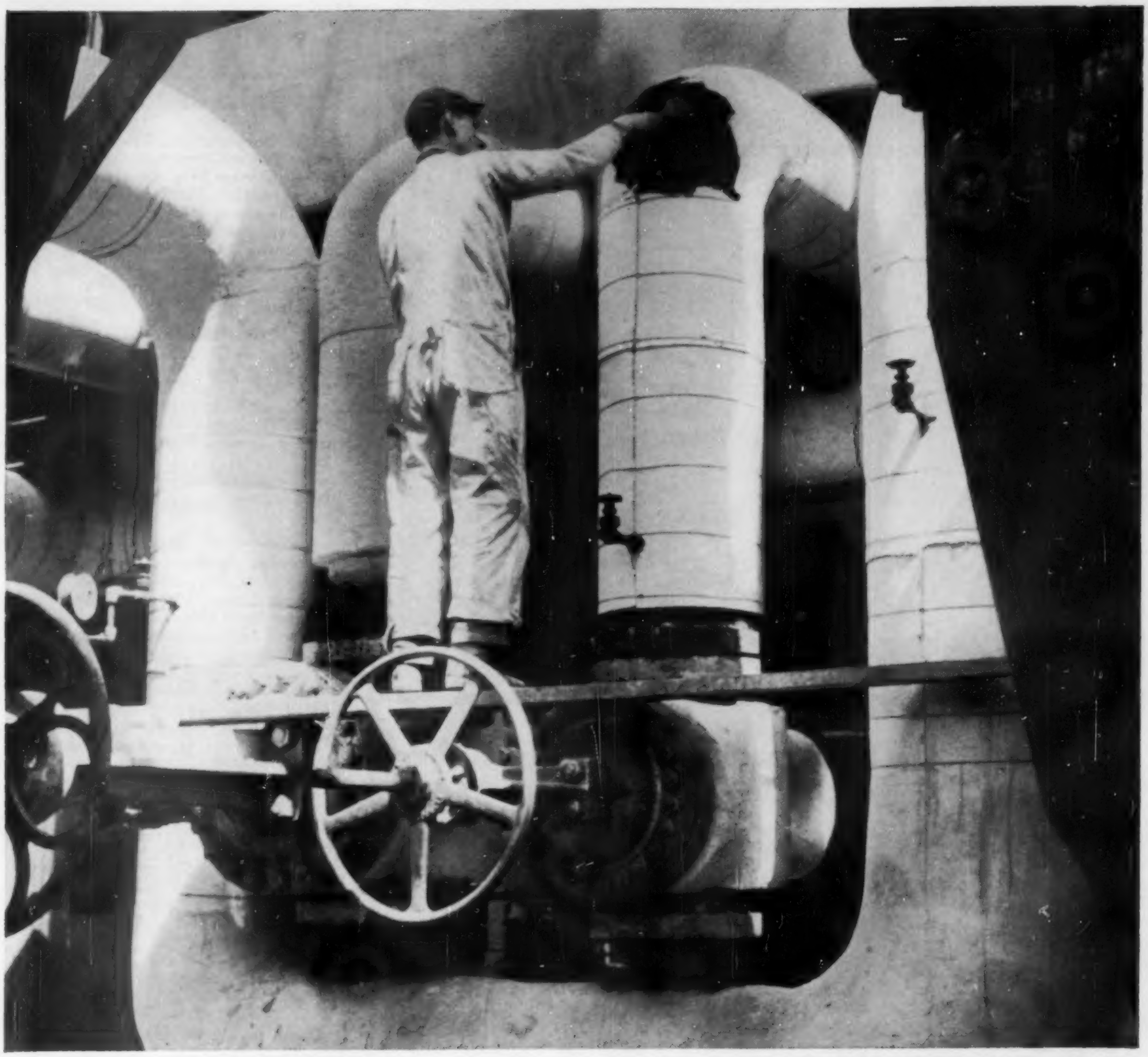
In Canada—Bailey Meter Company Limited, Montreal



J-M 85% Magnesia offers excellent workability
. . . from application to finished coat.

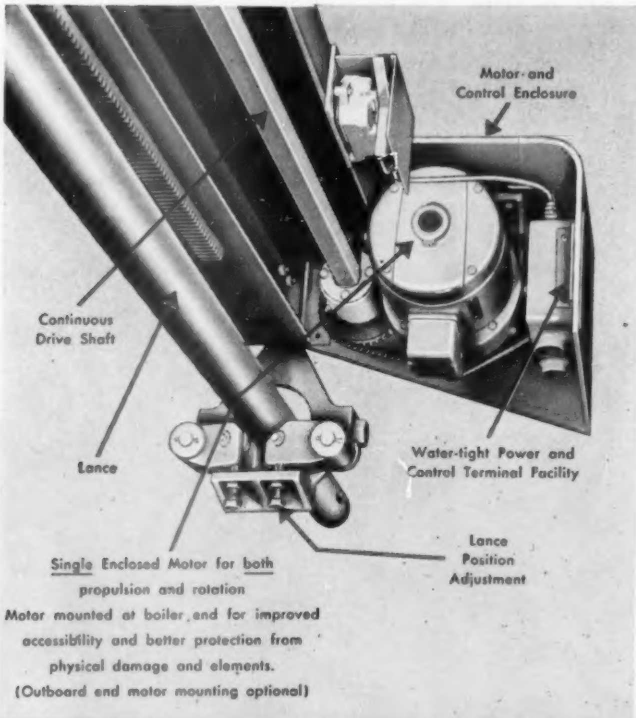
Advertisers' Index

(Continued on page 71)

FRONT END Single-Motor DRIVE

another important feature of

New Diamond Series 300 IK LONG RETRACTING BLOWER



As illustrated at the left, only *one motor* is used to simultaneously propel and rotate the lance tube of the new Series 300 IK. The motor is stationary and is mounted at the boiler wall for easier accessibility and greater protection from physical damage and the elements (note the protective enclosure). This front end single-motor drive is simple and dependable. There is only *one* set of motor elements . . . *one* set of control elements . . . and *one* set of power supply facilities to operate and maintain.

Additional important features of the new Series 300 IK are listed in the panel below. Check them and you will understand why this blower is establishing a new standard of efficiency, economy and dependability in cleaning those heating surfaces that require a long retracting blower. For further information about the new Series 300 IK, ask your local Diamond office or write directly to Lancaster for Bulletin 2111V.

OTHER ADVANTAGES OF SERIES 300 IK BLOWERS

- Backbone and Protective Cover
- Compact, Accessible Electric Power and Control Terminal Facilities
- Nozzle-Sweep-Every-Inch Cleaning Pattern
- Improved "Type A" Nozzle
- Positive Gear Carriage Drive
- Poppet Valve with Adjustable Pressure Control
- Positive Mechanically Operated Valve
- Single Point Outboard Suspension
- Oversize Lance (Step-Tapered for Extra Long Travel)
- Auxiliary Carriages for Extra Long Travel
- Designed for Quick, Easy Servicing

No other blower gives you all these advantages.

Diamond

DIAMOND POWER SPECIALTY CORPORATION

LANCASTER, OHIO

Diamond Specialty Limited
Windsor, Ontario

7765